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Developing a Yoga Programme for Older Adults in Scotland

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THE UNIVERSITY
of EDINBURGH

Thesis submitted for the degree of Doctor of Philosophy

Institute for Sport, PE & Health Sciences

The University of Edinburgh

2019

Declaration

I, Divya Sivaramakrishnan, hereby declare that:
a) I have composed this thesis, and that the work has not been submitted for any other degree or professional qualification.
b) This thesis is my own work, except where work which has formed part of jointly-authored publications has been included.
c) Appropriate credit has been given within this thesis where reference has been made to the work of others.

Chapter 3/Appendix 2:
Sivaramakrishnan, D., Fitzsimons, C., Kelly, P., Ludwig, K., Mutrie, N., Saunders, D. H., & Baker, G. (2019). The effects of yoga compared to active and inactive controls on physical function and health related quality of life in older adults-systematic review and meta-analysis of randomised controlled trials. International Journal of Behavioral Nutrition and Physical Activity, 16(1), 33. doi:10.1186/s12966-019-0789-2

I led all the work on this study and drafted the manuscript. Dr. Claire Fitzsimons and Dr. Graham Baker assisted in a supervisory capacity. Authors contributed to the study selection, data extraction and quality assessment stages, and provided inputs at all stages of the project.

Chapter 4/Appendix 15:
Sivaramakrishnan D, Fitzsimons C, Mutrie N, Baker G: Perceptions of Yoga among Older Adults: A Qualitative Approach. *Annals of Yoga and Physical Therapy* 2017, 2.

I led all the work on this study and drafted the manuscript. Dr. Claire Fitzsimons, Dr. Graham Baker and Professor Nanettte Mutrie assisted in a supervisory capacity.

Signed: Divya Sivaramakrishnan

Date: 10 June 2019

Acknowledgements

I would first like to thank my supervisors Dr. Claire Fitzsimons and Dr. Graham Baker for their support. For their encouragement during the demanding phases, and their patience and meticulous feedback on my writing of varying quality. For giving me a push when I needed it. And for their help with personal and professional issues I encountered as a student, and offering brilliant suggestions to make this journey smooth and enjoyable.

To Nanette for the many "quick chats". I am privileged to have access to your knowledge and experience, and for being able to pick your brains about the varied subjects that have cropped up during my PhD.

To my steering group for their help during my PhD. Dr. Maggie Lawrence for the numerous trips to Edinburgh, and valuable guidance. June Adamson, Claire Craig and Edinburgh Leisure staff for all the help with participant recruitment. I was always met with enthusiasm every time I requested your assistance.

To PAHRC for funding several training sessions/conferences, and covering my research costs. I'm grateful for the many opportunities to learn and contribute. Thanks to Dr. Paul Kelly and Dr. Samantha Fawkner for being encouraging yet strict reviewers during my progression boards. Every member of PAHRC has provided help and guidance at different points of my PhD, and I would like to acknowledge and thank them all.

To my systematic review research team including Kim Ludwig, Dr. Dave Saunders, and Dr, Paul Kelly, for all the inputs and hard work. Thanks to Marshal Dozier for providing technical support with the systematic review and NVivo.

A big thank you to all study participants, and to Dr. Yvonne Laird and Dr. Tasneem Irshad for their help as co-moderators.

I also want to thank my amazing family. My mom for the editing help and all the support throughout my PhD; Priya for all the sage advice and help with glossary illustrations; Dad for his generosity and support; Grandparents for believing in me and their blessings. I couldn't have got this far without your help.

My support system in Scotland- Veena and gang for meals and entertainment, Aishwarya for the coffees and chats, and Tsveti for listening to my PhD woes. Neil for weekend trips and much needed, amazing holidays. Rahul for always giving me high marks on my PhD progress.

So many people to thank, so little time. My heartfelt thanks to all of you.

Abstract

Current UK physical activity guidelines for older adults (65 years and above) recommend that they should aim to be active daily. Ideally, older adults should accumulate at least 150 minutes of moderate intensity activity per week in bouts of at least 10 minutes, or 75 minutes per week of vigorous activity for those who are already regularly active. Muscle strengthening activity is recommended on at least two days per week, and incorporating physical activity to improve balance and co-ordination on at least two days a week is recommended to those at risk of falls. The percentage of the Scottish older adult population achieving these guidelines is low. Recent data (2012-2014) suggests that only 14% of men and 12% of women in the 65-74 years age-group, and nine percent of men and four percent of women over 75 years met the muscle strength guidelines. The balance and coordination guidelines were met by 19% of older men and 12% of older women. Hence it is important to focus on improving adherence to muscle strengthening, and balance and coordination guidelines in this population. Moreover, targeted interventions should be developed to promote physical and psychological wellbeing among older adults.

Yoga is an ancient practice that originated in India. Research evidence shows that yoga has numerous physiological and psychological benefits for older adults, and is recommended in the UK physical activity guidelines as a muscle strengthening activity. Despite the benefits of yoga, only 4% of adults aged 65-74 years and 0% of those aged 75 years and above in Scotland participated in yoga in 2016. The overall objective of this PhD was to develop a yoga intervention that is appealing, acceptable and appropriate for older adults in Scotland, and to recommend strategies to encourage yoga participation in this population. Intervention development frameworks prescribe establishing the evidence base, consulting with stakeholders (e.g. target population), and identifying the theory of change. Based on this, four studies were undertaken. Study 1 was a systematic review and meta-analysis assessing the effects of yoga on physical function and health related quality of life (HRQoL) in older adults not characterised by any clinical conditions. Twenty-seven records from 22 RCTs were included in the systematic review. The meta-analysis

revealed significant moderate effects favouring the yoga group compared with inactive controls (e.g. wait-list control, education booklets) for physical function outcomes such as balance and lower body flexibility, and a small effect for lower limb strength. Compared with active controls (e.g., walking, chair aerobics) significant small effects favouring the yoga group were found for lower limb strength and lower body flexibility. For HRQoL, significant moderate effects favouring yoga were found compared to inactive controls for depression, perceived mental health, perceived physical health, and sleep quality; and small effects were found for vitality. Compared to active controls, a significant moderate effect was found for depression.

Study 2 adopted qualitative methods to explore the perceptions of yoga in Scottish older adults. Findings highlighted the apprehensions that older adults with no yoga experience may have with respect to yoga participation such as finding yoga difficult and demanding, lack of information around yoga, and fear of embarrassment. This study also developed guidance for instructors and strategies to promote yoga in the older adult population. A knowledge exchange event was conducted with yoga teachers, studio owners and researchers, where some of these findings were validated and new insights compiled.

Study 3 of the PhD project was a feasibility study to evaluate intervention components identified in Study 2. These intervention components were incorporated within three elements- a yoga taster session, a leaflet to promote yoga participation, and a handout to support home-based yoga practice. The experiences of a yoga instructor in delivering the taster session were also investigated. Focus groups, interviews and questionnaires with older adults and a yoga instructor were used to evaluate these elements. Overall, the yoga taster session was found to be appealing, acceptable and appropriate. Barriers such as apprehensions around finding yoga difficult, continuously getting down and up from the floor, and having heavy spiritual content were successfully addressed. Participants appreciated the leaflet and confirmed its potential as a promotional tool. It was felt that the home-based sessions could be useful in facilitating regularity of yoga practice. All three modes were effective in addressing the barrier relating to lack of information on yoga. The

instructor observed that the aims and principles of the programme were clear from the brief provided. He offered additional inputs such as emphasis on a non-violent approach, adding breathing exercises after the corpse pose, and suggestions for handing different capabilities during a session.

In Study 4, the final intervention was developed by combining components from studies 1, 2 and 3, and other relevant published literature. Intervention components were compiled under the following categories: (i) Yoga is difficult and demanding (ii) Continuous movement between getting up and down from the floor (iii) Class content details (class structure, poses to include and avoid, home-based session details) (iv) Breathing/spiritual content (v) Guidance for instructors (vi) Social interaction (vii) Class details (class environment, class size, duration and frequency, name, age-group) (viii) Yoga promotion strategies. Two theory of change models were developed. The first examined how the identified yoga promotion strategies could lead to increased participation or recruitment to a yoga programme, and the second explored how the programme components could improve adherence to a yoga programme.

Findings from this PhD suggest that yoga is effective in improving physical and psychological wellbeing in older adults including flexibility, strength and balance. An appealing, appropriate and acceptable intervention for older adults has been developed, and strategies to encourage yoga participation among this population are suggested. Intervention components developed are of value to yoga instructors, programme developers and researchers working with an older adult population. Future studies could include further feasibility testing, a pilot study and a large-scale intervention.

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Funding

My PhD is funded by the College PhD Scholarship from the Moray House School of Education, University of Edinburgh. The award is tenable for three years, starting on 1st October 2015.

Supervisory Arrangement

I am a member of the Physical Activity for Health Research Centre (PAHRC). When I started my PhD in October 2015, my supervisors were Dr. Claire Fitzsimons and Professor Nanette Mutrie. In November 2015, Dr. Graham Baker joined the supervisory team. Professor Mutrie moved out of the supervisory role in September 2016, but continued to provide advice and remained on the project steering committee.

The project benefitted from the experience and expertise of a steering committee which included the supervisory team, Professor Nanette Mutrie, Dr. Maggie Lawrence (Senior Research Fellow, Institute for Applied Health Research, Glasgow Caledonian University), Professor Chris Oliver (Surgeon at the Royal Infirmary Edinburgh and Honorary Professor of PAHRC, University of Edinburgh), June Adamson (Senior Instructor, Quality Assurance & Training, Sport and Exercise, University of Edinburgh) and Lorraine Close (Yoga teacher and clinical skills facilitator, University of Edinburgh). The committee met in November 2016. After this, I engaged with the committee members individually to get their advice and feedback.

Personal Background to the PhD

I started teaching yoga in 2008. Feedback from students made me realise that physical activity (PA) has a positive impact on physiological and psychosocial wellbeing. In 2012, I took up a Master's programme in Sport and Health Sciences (University of Exeter) to further my understanding of the effects of PA, and hone my research and academic writing skills. I was then inspired to pursue research, and was particularly interested in PA across the life span, and promotion of PA. I enrolled for a PhD program as this would bring together my interest in research methods, and

passion to explore PA (more specifically yoga) and health. With age, my own teaching style has been changing and I have moved from a fast-paced power yoga style, to a more holistic practice focusing on energy, mobility, and psychological aspects. It became obvious to me that yoga is an ideal type of PA for older adults, with benefits I had read about and experienced myself such as improved mobility, strength, balance, reduced stress and improved sleep. I have never taught a yoga session intended specifically for older adults, but the few who have attended my group classes and one-to-one sessions have found it useful. I have also seen my parents and grandparents gain substantial benefits from practicing yoga. My main motivations for undertaking this PhD were:

- To delve into yoga for older adults and understand if it's a viable PA option for older adults in Scotland
- To contribute to research in the field of PA and health
- Cultivate the skills to develop and evaluate PA interventions

The vision and research themes at the Physical Activity for Health Research Centre mirrored my research interests, and I am lucky to have had the opportunity to pursue my PhD within this department.

Maintaining Objectivity

Although I am a yoga teacher, and an enthusiastic practitioner, I have strived to conduct this research project in an unbiased manner. Objectivity was maintained by adopting rigorous research methods and meticulous reporting. I would also like to mention that as a PA researcher, my final objective is to increase PA levels, physical function and psychological outcomes among older adults. While I think that yoga is one route to achieving this, I am aware that not everyone would find it appealing, and may prefer other options. I believe it is very important to adopt appropriate research methods and reporting practices to reduce bias and achieve the final goal.

Word Count

Abstract:	970
Preface material:	3388
Main text:	95180
Thesis word count (main text + preface material):	98568
References:	9410

Abbreviations

US	United States
UK	United Kingdom
CVD	Cardiovascular disease
PA	Physical activity
WHO	World Health Organization
MET	Metabolic Equivalent MET
%HR Max	Percentage of maximum heart rate
%VO2 Max	Percentage of maximum oxygen uptake
RPE	Rate of perceived exertion
SLOTH	Sleep, Leisure-time, Occupation, Transportation, and Home-based activities
MVPA	Moderate to vigorous activity
MS	Muscle strength
BC	Balance and co-ordination
SB	Sedentary behaviour
HR	Hazard ratio
ACSM	American College of Sports Medicine
HDL	High-density lipoproteins
BMI	Body mass index
RCT	Randomized control trials
HRQoL	Health Related Quality of Life
ES	Effect size
SMD	Standardised mean difference
BMD	Bone mineral density
VLDL	Very low-density lipoprotein
HbA1c	Glycated haemoglobin
LDL	Low-density lipoprotein
COPD	Chronic obstructive pulmonary disease
FEV1	Forced expiratory volume in one second
6 MWD	Six-minute walking distance
SNS	Sympathetic Nervous System
ITT	Intention to treat
CONSORT	Consolidated Standards of Reporting Trials
FICSIT-4	Frailty and Injuries: Cooperative Studies of Intervention Techniques
SF-36	36-Item Short Form Health Survey
WHOQOL	The World Health Organization Quality of Life
RESET	Relevance, Evidence base, Stages of intervention, Ethnicity, and Trends
MRC	Medical research council

6SQuID	Six steps in quality intervention development
TRA	Theory of reasoned action
TPB	Theory of planned behaviour
PMT	Protection motivation theory
SCT	Social cognitive theory
SDT	Self-Determination Theory
TTM	transtheoretical model
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
COREQ	COnsolidated criteria for REporting Qualitative research
KE	Knowledge exchange
POMA	Performance Oriented Mobility Assessment
CI	Confidence interval
BWY	British Wheel of Yoga
PICOS	Population; Intervention/Control; Outcome; Study
LGBT	Lesbian, gay, bisexual, and transgender
YP	Yoga Participants
NYP	Non-yoga participants
IPAQ-SF	International Physical Activity Questionnaire
NHS	National Health Service
PAR-Q	Physical Activity Readiness Questionnaire
JMOF	Joint moment of force
EMG	Electromyographic
MVIC	Maximum voluntary isometric contractions
EX	Exercise
BCTs	Behaviour Change Techniques
OECD	Organisation for Economic Co-operation and Development
REACT	REtirement in ACTion
QALYs	Quality-adjusted life years
EQ-5D_5L	EuroQoL five dimension five level
CEA	Cost-effectiveness analyses
SAMH	Scottish Association for Mental Health

Overview

This PhD thesis consists of eight chapters. Chapter 1 provides a background to the thesis, and specifies the objectives of the PhD. Chapter 2 outlines the broad methodology adopted in the thesis. This chapter discusses the theory underpinning the yoga programme under development, and an initial theory of change model for the programme is presented. The structure of the thesis and studies undertaken are also detailed in this chapter. Chapter 3 (Study 1) is a systematic review and meta-analysis of the effects of yoga on physical functioning and health related quality of life in older adults not characterised by a specific disease or health condition. The bulk of this chapter is in the form of a published manuscript, and the final author manuscript is presented in this chapter. Chapter 4 deals with consultations with the target population and stakeholders. This chapter consists of two parts: (i) Study 2: focus groups and interviews with older adults to understand their perceptions of yoga and (ii) Knowledge exchange event: conducted with stakeholders such as yoga teachers and studio owners. In Chapter 5 (Study 3), some components identified in Chapter 4 were evaluated to assess their appeal, appropriateness and acceptability to older adults. Chapter 6 (Study 4) collates findings from Studies 1-3 and other relevant research to develop a final yoga programme. In Chapter 7 (Study 4 continued), two theory of change models were developed to understand how the developed programme would achieve final outcomes. A summary and discussion are presented in the final chapter (Chapter 8). Applications of the findings and recommended next steps are considered.

Chapter 1. Background and Objectives

This chapter provides an overview of (i) older adults: definition and characteristics (ii) physical activity: definitions, benefits, guidelines, and levels (iii) yoga: background, benefits, and prevalence. The rationale and objectives of the PhD are then defined.

1.1 Who is an Older Adult?

In most developed countries, the accepted chronological age that defines an older person is 65 years and above (World Health Organisation, 2002). There is still variation in the definition adopted by organisations, for example the United Nations categorises those aged 60 years and above as older persons (Department of Economic and Social Affairs, 2017). The physical activity guidelines of Canada, Germany, United States (US) and United Kingdom (UK) have defined older adults as those aged 65+ years (2018 Physical Activity Guidelines Advisory Committee, 2018). In the UK Chief Medical Officer's report on physical activity (Department of Health, 2011), the age threshold for older adults is 65+ years. Therefore, this definition will be adopted within this PhD unless otherwise specified.

1.2 Older Adult Population Demographic and Health Characteristics

In 2017, older adults comprised 8.7% of the world population (The World Bank, n.d.). This is projected to increase to 11.6 % by 2030 (Pew Research Center, 2014). Adults aged 65 years and above constituted 18.2% of the UK population in 2016, and this is projected to increase to 24% in 2037 (Office for National Statistics, 2018a).

Global life expectancy in 2016 was 74.2 years for females and 69.8 years for males (World Health Organization, n.d.), with life expectancy in the UK (2015-2017) higher at 82.9 years among females and 79.2 years among males (Office for National Statistics, 2018b). In the UK, the tax contribution from people of working age is greater than consumption in terms of public spending (Office for National Statistics, 2018c). This trend shifts in later life where consumption of welfare spending such as pensions, health and

social care outweighs tax contribution (Office for National Statistics, 2018c). Healthcare costs increase rapidly at around 65 years (Office for National Statistics, 2018c).

Ageing is associated with increased risk of injury (Jin, 2018) and non-communicable diseases (World Health Organization, 2011b). In England and Wales, 5,048 older adults died from a fall in 2017 (Office for National Statistics, 2018d), and falls are the largest cause of emergency hospital admissions in this population (Age UK, 2018). The economic burden of non-fatal and fatal falls in adults over 60 years living in the community was estimated to be $23.3 billion in the US and $1.6 billion in the UK (Davis et al., 2010). In 2011, the prevalence of cardiovascular disease (CVD) was 22.5% (65-74 years) and 29.8% (75+ years) among women, and 28.5% (65-74 years) and 34.1 (75+ years) among men (Townsend, Bhatnagar, Wilkins, Wickramasinghe, & Rayner, 2015). The incidence of stroke increases with age, with the 65+ years age group in the UK accounting for 93% of the total deaths from stroke in 2010 (Stroke Association, 2013). The older adult population is also affected by social isolation and mental health disorders (World Health Organization, 2015). Twenty two percent of older men and 28% of older women in the UK are affected by depression (Craig & Mindell, 2007). Dementia is another leading cause of disability and dependency among older adults in the UK (Age UK, 2018), and age is the biggest risk factor for dementia. Globally, 47 million people live with dementia and this is projected to increase to 75 million by 2030 (World Health Organization, 2018a). In the UK, it was estimated that in 2013 one in every 14 older adults had dementia (Prince et al., 2014).

Ageing is accompanied by other physiological and psychological changes (World Health Organization, 2015). Although there is variation in how these are experienced by individuals, some general changes associated with ageing are reduced muscle mass, strength, bone mass or density; and also an increased risk of osteoporosis in post-menopausal women (World Health Organization, 2015). Muscle strength, bone strength and balance ability increase in childhood, peak in early adulthood, and eventually decline with age (Skelton & Mavroeidi, 2018). These factors can affect musculoskeletal function and movement such as gait speed (World Health Organization, 2015). Reduced vision and hearing are linked to ageing, which

can further lead to social isolation, loss of autonomy, anxiety, depression and cognitive decline (World Health Organization, 2015).

It is thus important to adopt strategies to fight the non-communicable disease epidemic, improve and maintain functional capacity and promote physical and psychological wellbeing among older adults. The promotion of physical activity (PA) has been identified as a priority area by the World Health Organization (WHO) to enable healthy ageing (World health Organization, 2012). A strategic objective in the Global Action Plan on Physical Activity 2018 - 2030 is to increase opportunities to participate in PA in the least active groups such as older adults (World Health Organization, 2018b) .

1.3 Definition of Physical Activity

In the special issue on PA published in The Lancet journal in 2012 (Das & Horton, 2012), the series was described as follows:

"This series on physical activity is not about sport and it is about more than just exercise. It is about the relationship between human beings and their environment, and about improving human wellbeing by strengthening that relationship. It is not about running on a treadmill, whilst staring at a mirror and listening to your iPod. It is about using the body that we have in the way it was designed, which is to walk often, run sometimes, and move in ways where we physically exert ourselves regularly whether that is at work, at home, in transport to and from places, or during leisure time in our daily lives." (Das & Horton, 2012, p.189)

Although this excerpt describes the series on PA in the Lancet (Das & Horton, 2012), it can be regarded as a profound description of physical activity, very pertinent to the modern age.

PA is defined by Caspersen, Powell, and Christenson (1985) as comprising of four elements:

- Body movement produced by the skeletal muscles
- Resulting in energy expenditure

- Energy expenditure measured in kilocalories varies from low to high
- Having a positive correlation with physical fitness

Although the term exercise is often used interchangeably with PA, it is considered a sub-category of physical activity within Caspersen's definition (Caspersen et al., 1985), with two additional elements-

- The body movement should be planned, structured and repetitive
- Have an objective of improving or maintaining components of physical fitness

PA can be performed at various intensities, and undertaken in different contexts. The different intensities and domains of PA are described in the subsequent sections.

1.4 Physical Activity Intensity

Intensity of PA can be measured in absolute or relative terms (Garber et al., 2011). Absolute classifications use measures like caloric expenditure (kcal/min), absolute oxygen uptake (mL/min), and metabolic equivalent (MET) (index of energy expenditure defined as the ratio of the rate of energy expended during an activity to the rate of energy expended at rest (Garber et al., 2011)). Relative measures include percentage of maximum heart rate (%HRmax), percentage of maximum oxygen uptake (%VO_2max), and perceived exertion (RPE) measured by the Borg Rating of Perceived Exertion scale. Table 1 shows the %HRmax, %VO_2max, RPE and MET values for commonly used categories of exercise intensity.

Table 1

The %HRmax, %VO2max, RPE and MET values for each exercise intensity

Intensity	%HRmax	%VO_2max	RPE (6-20 RPE scale)	METs
Very light	<57	<37	Very light: <9	<2
Light	57-63	37-45	Very light to fairly light: 9-11	2.0-2.9
Moderate	64-76	46-63	Fairly light to somewhat hard: 12-13	3.0-5.9
Vigorous	77-95	64-90	Somewhat hard to very hard: 14-17	6.0-8.7
Near maximal to maximal	≥ 96	≥ 91	Very hard: ≥ 18	≥ 8.8

Note. Adapted from "Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise", by Garber et al., 2011, *Medicine & Science in Sports & Exercise*, 43(7), p.1341. Copyright 2011 by American College of Sports Medicine
%HRmax = percentage of maximum heart rate, %VO2max = percentage of maximum oxygen uptake, RPE = perceived exertion, MET = metabolic equivalent

1.5 Physical Activity Domains

PA could be undertaken for various reasons. The SLOTH model categorises the hours of the day into five domains within which individuals may choose to be physically active or inactive (Pratt et al., 2004). The five domains are: Sleep, Leisure-time, Occupation, Transportation, and Home-based activities. Scottish PA levels are reported annually by the Scottish Health Survey, which records PA under the domains of domestic, occupational, sport and exercise, and walking (Currie, 2017).

1.6 Importance of Physical Activity

The Global Burden of Disease Study reported that physical inactivity was among the top 10 risk factors for burden of disease, and accounted for 3.2 million deaths worldwide (Lim et al., 2012). Lee et al. (2012) estimated that physical inactivity caused 9% of premature mortality worldwide in 2008. They also found that 6% of the burden of disease from coronary heart disease, 7% of type 2 diabetes, 10% of breast cancer, and 10% of colon cancer could be attributed to physical inactivity. Kyu et al. (2016) quantified the dose-response associations between total PA and risk of several chronic diseases. Higher levels of total PA were found to be significantly associated with lower risk for all outcomes (Figure 1). Compared with insufficient PA levels (<600 MET minutes/week), the risk reductions for those engaging in high

levels of PA (≥ 8,000 MET minutes/ week) were 14% for breast cancer; 21% for colon cancer; 28% for diabetes (type not specified in the study); 25% for ischemic heart disease; and 26% for ischemic stroke. Major health gains could also be accrued at lower levels of activity, and individuals achieving the minimum recommended level of 600 MET minutes/week had a 2% lower risk of diabetes compared with those reporting no PA. An increase from 600 to 3,600 MET minutes/week reduced the risk by an additional 19%. To contextualise this, home activities such as washing dishes equates to 1.8 MET, walking at the speed of 2.5 meters per hour on a level surface is 3 MET, and marathon running is 13.3 MET (Ainsworth et al., 2011).

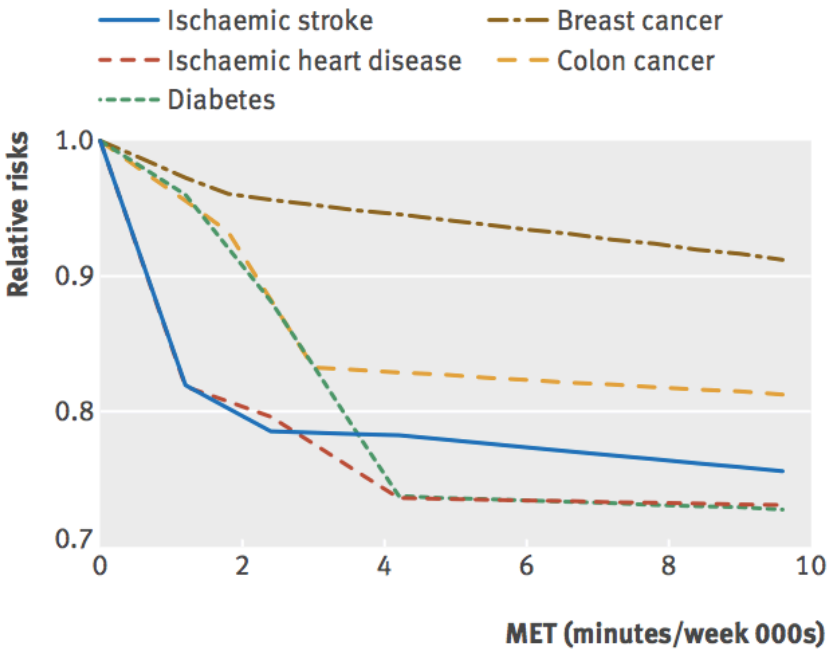


Figure 1. Continuous risk curves for association between physical activity and breast cancer, colon cancer, diabetes, ischemic heart disease, and ischemic stroke. Reprinted from "Physical activity and risk of breast cancer, colon cancer, diabetes, ischemic heart disease, and ischemic stroke events: systematic review and dose-response meta-analysis for the Global Burden of Disease Study 2013" by Kyu et al., 2016, *BMJ, 354 (i3857), 7.* Copyright [2016] by BMJ Publishing Group Ltd. Reprinted with permission.

Several other reviews have examined the relationship between PA and all-cause mortality as well as chronic diseases such as CVD, diabetes, and several types of cancer (Milton, Macniven, & Bauman, 2014; Warburton, Charlesworth, Ivey, Nettlefold, & Bredin, 2010). Milton et al.(2014) conducted a systematic review of the epidemiological evidence linking PA and health in low and middle-income

countries. They found consistent associations between PA and reduced risk of all-cause mortality, CVD, diabetes (type not specified in the study) and several types of cancer (Milton et al., 2014). The review also found favourable associations between PA and body composition (including overweight and obesity), blood pressure, cholesterol, metabolic indices and bone mineral density.

Using a cross-sectional design, a recent study estimated the associations between exercise and mental health burden in a large US sample (Chekroud et al., 2018). Individuals who exercised were found to have fewer days of poor mental health in the past month compared to individuals with similar physical and sociodemographic profiles who did not exercise.

1.7 UK Physical Activity Guidelines for Older Adults

One of the earliest PA guidelines for public health were issued in 1995 with the aim of encouraging PA participation among Americans (Pate et al., 1995). It was recommended that adults undertake a minimum of 30 minutes of at least moderate intensity aerobic activity on most, preferably all days of the week, which could be accumulated in bouts of 8-10 minutes. Adults were also recommended to undertake regular muscle strengthening activity.

The UK 2004 "At least five a week" guidelines (Department of Health, 2004) developed by the Department of Health was considered a landmark document (Milton & Bauman, 2015), and included recommendations for active living throughout the life course. Adults were recommended to achieve at least 30 minutes a day of at least moderate intensity PA on five or more days of the week. The daily activity levels could be achieved through several bouts of activity of 10 minutes or more or just in one session. The 2004 guidelines introduced recommendations for older adults. Over and above the adult recommendations, older adults should also take care to keep moving and retain their mobility through daily activity. Additionally, activities that promoted improved strength, co-ordination and balance were recommended as particularly beneficial for older people.

In 2011, the UK physical activity guidelines were updated in the Chief Medical Officers' report (Department of Health, 2011). The physical activity guidelines for older adults (65+ years) included:

1. Moderate to vigorous activity (MVPA) or aerobic guidelines: Older adults should participate in at least 150 minutes of moderate intensity activity per week in bouts of 10 minutes or more. Comparable benefits can be achieved through 75 minutes of vigorous intensity activity spread across the week or a combination of moderate and vigorous activity.
2. Muscle strength (MS) guidelines: Physical activity to improve muscle strength should be undertaken on at least two days a week.
4. Balance and co-ordination (BC) guidelines: Older adults at risk of falls should undertake physical activity to improve balance and co-ordination on at least two days a week.
5. Some physical activity is better than none, and more physical activity provides greater health benefits.
6. Sedentary behaviour (SB) guidelines: Older adults should minimise time spend being sedentary for extended periods

The WHO guidelines for older adults (World Health Organization, 2011a) include MVPA recommendations similar to the UK. The guidelines also suggest that for additional health benefits, older adults should increase their moderate-intensity aerobic PA to 300 minutes per week, or engage in 150 minutes of vigorous-intensity aerobic PA per week, or an equivalent combination of moderate and vigorous intensity activity. Older adults with poor mobility, are recommended to perform PA to enhance balance and prevent falls, on three or more days per week. MS activities involving major muscle groups, are recommended on two or more days a week. If older adults cannot meet these recommendations, they should be as physically active as their abilities and conditions allow.

The PA guidelines for Americans were recently published (U.S. Department of Health and Human Services, 2018)-

Guidelines for adults and older adults:

(1) Move more and sit less throughout the day. Some PA is better than none.
(2) Adults should do at least 150 minutes to 300 minutes a week of moderate-intensity, or 75 minutes to 150 minutes a week of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity aerobic activity. Preferably, aerobic activity should be spread throughout the week.
(3) Additional health benefits are gained by engaging in PA beyond the equivalent of 300 minutes of moderate-intensity PA a week.
(4) Adults should also do MS activities of moderate or greater intensity that involve all major muscle groups on 2 or more days a week.

Guidelines just for older adults:
(1) Older adults should do multicomponent PA that includes balance training as well as aerobic and MS activities weekly.
(2) Older adults should determine their level of effort for PA relative to their level of fitness.
(3) Older adults with chronic conditions should understand whether and how their conditions affect their ability to do regular PA safely.
(4) When older adults cannot do 150 minutes of moderate-intensity aerobic activity a week because of chronic conditions, they should be as physically active as their abilities and conditions allow.

PA guidelines are currently being updated in the UK. Since the new guidelines will be published only in 2019, this PhD uses the current UK PA guidelines (Department of Health, 2011, 2016) as the primary reference.

1.8 Benefits of Aerobic Physical Activity for an Older Adult Population

1.8.1 All-cause mortality and chronic diseases. Research evidence shows that PA is associated with a reduction in all-cause mortality. In a prospective population-based survey of 5,278 Spanish older adults (≥ 65 years), participating in PA was associated with a lower risk of all-cause mortality when compared to the inactive group after controlling for several covariates (Llamas-Velasco et al., 2016). Compared to the inactive group, hazard ratios (HR) (probability of mortality in PA

group compared with probability of mortality in inactive group) were 0.64 for light PA, 0.61 for moderate PA, and 0.48 for high PA groups. A study with a prospective cohort design involving 7,080 women and 11,688 men from Australia found that PA was inversely associated with all-cause mortality in older men and women (Brown et al., 2012). A systematic review and meta-analysis investigated the relationship between lower doses of aerobic activity (1 – 499 MET-minutes) and mortality in adults aged 60 years and above (Hupin et al., 2015). The review included 122,417 participants from nine cohorts, and found that a 22% reduction in mortality risk could be gained from a low dose of aerobic activity. Higher aerobic PA levels resulted in further risk reductions. The review concluded that even low doses of PA could yield significant health benefits.

The UK Chief Medical Officers' report on PA (Department of Health, 2011) concluded that there was strong evidence that physically active adults aged 65 years and over have improved disease risk factor profiles, and lower incidence of numerous chronic non-communicable diseases than those who are inactive. The American College of Sports Medicine (ACSM) Position Stand on PA and exercise for older adults (Chodzko-Zajko et al., 2009) also reviewed evidence and reported that regular PA is associated with reduced risk of developing CVD, stroke, hypertension, type 2 diabetes, osteoporosis, obesity, colon cancer and breast cancer.

Associations between PA intensity measured through accelerometery (categorised as low light, high light, moderate to vigorous PA) and CVD risk factors were examined in a study that included 4,832 older women (LaMonte et al., 2017). It was found that each PA category was favourably associated with mean high-density lipoproteins (HDL), triglycerides, glucose, C-reactive proteins, body mass index (BMI) and waist girth after adjusting for confounding factors. Although limited by a cross-sectional design, authors concluded that light and moderate to vigorous PA were associated with better CVD risk factor levels, and lower predicted 10-year CVD risk in race and ethnically diverse older women.

Vogel et al. (2009) reviewed the health benefits of aerobic PA in older adults. The review found that regular moderate intensity PA in older people is associated with a reduction in total mortality, and has a positive effect on the prevention of coronary heart disease, improved lipid profile, reduction in fat mass, reduced blood pressure, and prevention of stroke and type 2 diabetes.

1.8.2 Maintenance of independence, fitness, bone density, muscle mass, and falls prevention. The US Physical Activity Guidelines Advisory Committee Scientific Report (2018 Physical Activity Guidelines Advisory Committee, 2018) found strong evidence for an inverse dose-response relationship between the volume of aerobic PA and risk of physical function limitations in the general (without chronic conditions) aging population. Bouaziz et al. (2017) systematically reviewed the health benefits of aerobic training in adults aged 70 years and above and found consistent evidence supporting positive effects of aerobic PA on cardio respiratory fitness, hypertension, and functional outcomes such as MS, physical performance and the risk of falling.

Paterson and Warburton (2010) reviewed prospective cohort studies to establish the association between PA and outcomes of functional limitations, disability, or loss of independence in community dwelling older adults. They concluded that there is consistent evidence of regular aerobic PA conferring reduced risk of functional limitations and disability among older adults. Moderate to higher PA levels (which equates to 150 to 180 min/week and approximating 1000 kcal/week; 4200 kJ/week) was associated with 50% risk reductions in functional limitations and disability. Another systematic review of randomised controlled trials (RCT) used a narrative synthesis approach to assess the effectiveness of exercise interventions in manging frailty in older adults (de Labra, Guimaraes-Pinheiro, Maseda, Lorenzo, & Millán-Calenti, 2015). The review provided evidence that physical exercise has positive effects on outcomes such as balance, MS, body composition and frailty status in frail older adults.

Only limited evidence (due to a small number of studies and diverse ways in which the amount of PA was operationalised) was found by the 2018 Physical Activity Guidelines Advisory Committee (2018) to suggest that a dose-response relationship exists between the amount of MVPA and risk of fall-related injury and bone fracture. They also concluded from the evidence that lower amounts of moderate-intensity PA and walking may be insufficient to reduce the risk of fall-related injury and bone fracture in older adults. However, the committee found strong evidence to suggest that multicomponent PA regimens combining aerobic, strength, and balance training can significantly reduce the risk of injury from falls, including severe falls that result in bone fracture, and other injuries requiring medical care or admission to hospital.

1.8.3 Psychological and quality of life outcomes. Bize, Johnson, and Plotnikoff (2007) conducted a systematic review of the relationship between PA levels and Health Related Quality of Life (HRQoL) in a general older adult population. Seven cross-sectional studies, two cohort studies, and four RCTs were included in the review. A consistently positive association between self-reported PA and HRQoL was found among cross-sectional studies. No conclusions could be drawn from RCTs and cohort studies as they were limited in number with poor methodological quality.

Evidence suggests that PA has an anti-depressant effect, and improves emotional, cognitive, social and perceived physical function of older adults (Taylor et al., 2004). Hamer and Chida (2009) reviewed studies with a prospective design to understand the association between PA and risk of neurodegenerative diseases. They found that PA reduces the risk of dementia and Alzheimer's disease by 28% and 45% respectively. The evidence base for estimating the association between PA and Parkinson's disease was smaller, and PA was not associated with a significant reduction in the risk of Parkinson's disease. Another systematic review of RCTs assessed the effects of physical exercise on quality of life in older adults with depression or Alzheimer's disease (Tavares, Moraes, Deslandes, & Laks, 2014). They included six studies (four studied depression and two studied Alzheimer's

disease), and found evidence that physical exercise can improve quality of life in these subjects. A systematic review was conducted by Windle, Hughes, Linck, Russell, and Woods (2010) to examine the effects of PA on mental health in older adults. Studies with a comparison or control group, as well as qualitative studies were included. A meta-analysis was conducted including 4 eligible studies, and an overall significant small effect (Effect Size (ES) (Standardised Mean Difference (SMD)) = 0.27) of exercise on mental well-being was found.

1.9 Benefits of Muscle Strength and Balance and Co-ordination Activities

PA guidelines for older adults include performing MS activities on at least two days a week (Department of Health, 2011). Based on a literature review, Skelton and Mavroeidi (2018) presented recommendations for age and transition points when muscle and bone strengthening and balance activities were most important. Older adults were found to be an age-group for which these recommendations are especially important as balance, muscle and bone strength are critical to maintaining independence, preventing the risk of falls, fractures, and frailty. Data from the Health Survey for England and the Scottish Health Survey from 1994–2008 were used to estimate associations between participation in MS activities and all-cause, cancer, and CVD mortality (Stamatakis et al., 2018). Adhering only to the MS guidelines was found to reduce the risk of all-cause (HR = 0.79) and cancer mortality (HR = 0.66). Adhering only to the aerobic activity guidelines was associated with reductions in the risk of all-cause (HR = 0.84) and CVD (HR = 0.78) mortality. Adherence to both guidelines was associated with an even lower risk for all-cause (HR = 0.71) and cancer (HR = 0.70) mortality. The study emphasised the importance of the MS guidelines, and recommended promoting adherence to both MS and MVPA guidelines. Participating in MS activities was found to reduce the risk of type 2 diabetes in a Japanese working population, and the association was even more pronounced with a lower risk for individuals aged 50 years or older (Kuwahara et al., 2015).

Foster and Armstrong (2018) conducted a search of systematic reviews and meta-analysis of RCTs to assess the effectiveness of different types of PA on muscle, bone and balance outcomes. The review of reviews found consistent evidence that

strength/resistance training as a single intervention or in combination with other activities, performed on two/three occasions per week, was effective for muscular strength. Higher intensities of training produced greater gains. There was consistent evidence showing that strength training either as a single intervention or in combination with high impact loading activities, at least three times per week was effective for bone health. For balance training and falls reduction, PA with a high challenge to balance (activities which moved the centre of mass, narrowed the base of support and reduced upper limb support) done in standing three times per week were found to be beneficial.

Benefits of performing MS activities in older adults include the offsetting of age-related muscle loss (sarcopenia), enhanced functional performance, improved bone mineral density (BMD), and prevention of falls (Kelley, Kelley, & Tran, 2001; Lang et al., 2010). Older adults are at a high risk of falls, and the increasing economic impact of falls is a public health concern in the UK (Scuffham, Chaplin, & Legood, 2003). Gait and balance disorders are identified as a risk factor for falls (Rubenstein, 2006). A systematic review by Sherrington et al. (2008) aimed to identify specific features of exercise programmes that were associated with reductions in falls. Balance training was identified as a factor associated with the efficacy of exercise programmes in reducing fall rates. Hence, adherence to the MS and BC guidelines is extremely important for the older adult population.

1.10 Physical Activity Patterns

A recent study reported that 27.5% of adults worldwide did not achieve the recommended levels of aerobic PA in 2016 (Guthold, Stevens, Riley, & Bull, 2018). The study also reported that women were less active than men, with a prevalence difference of 8 percentage points between sexes. The prevalence of insufficient PA in high-income countries was found to have increased over time from 2001 (31.6%) to 2016 (36.8%), and was more than double the prevalence in low-income countries (16.2% in 2016) which remained stable during this time-period.

Hallal et al. (2012) studied global PA patterns based on data from 122 countries for adults (≥ 15 years), and 105 countries for adolescents (13-15 years).

They observed that physical inactivity increases with age. In England (Scholes, 2017), 67% of adults aged 19 to 64 years met the aerobic guidelines in 2016 (71% of men; 63% of women) in comparison to only 44% of older adults (65 years and over) (48% of men; 41% of women). This skew in PA trends is also apparent in Scotland with older adults (65+ years) achieving the lowest aerobic PA levels of any age group (Figure 2) (Currie, 2017). This was also demonstrated in the study by Strain, Fitzsimons, Foster, et al. (2016) who analysed 2013 Scottish Health Survey data to show that 53% of men and 66% of women over 65 years in Scotland did not meet the MVPA recommendations.

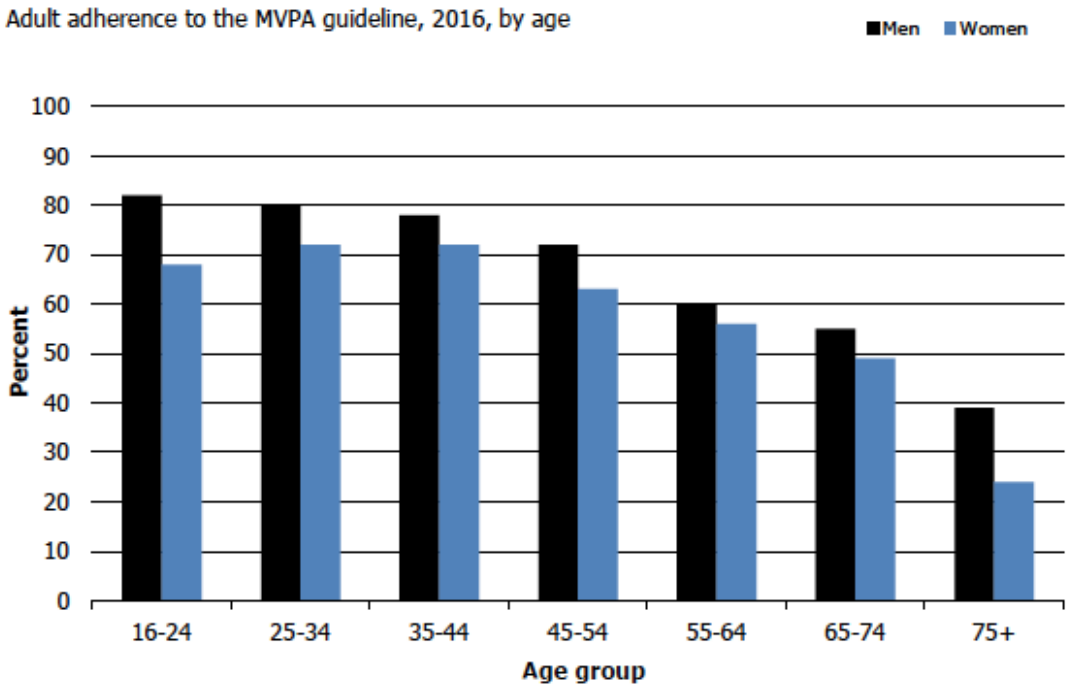


Figure 2. Adult adherence to the MVPA guideline in Scotland by age and sex. Reprinted from Chapter 3: Physical Activity, Scottish Health Survey 2016: Volume 1: Main Report, by Currie, 2017, Edinburgh: Scottish government. Reprinted with permission from the Scottish Government
MVPA: Moderate to Vigorous Physical Activity

1.11 Muscle Strength and Balance and Co-ordination Levels

In England, 15% of adults aged 65-74 years and 6% of those aged 75+ years met both MVPA and MS guidelines in 2016 (Scholes, 2017). Only 1% of adults aged 65-74 years and 2% of those aged 75+ years met MS but not MVPA guidelines (Scholes, 2017). Strain, Fitzsimons, Kelly, and Mutrie (2016) estimated adherence to MS and BC guidelines in Scotland using the Scottish Health Survey data (2012-

2014). The percentage of the population who did not undertake any MS sessions per week increased with age (Figure 3). Only 14% of men and 12% of women in the 65-74 age-group, and nine percent of men and four percent of women over 75 years met the MS guidelines. The BC guidelines were met by 19% of older men and 12% of older women (Figure 4).

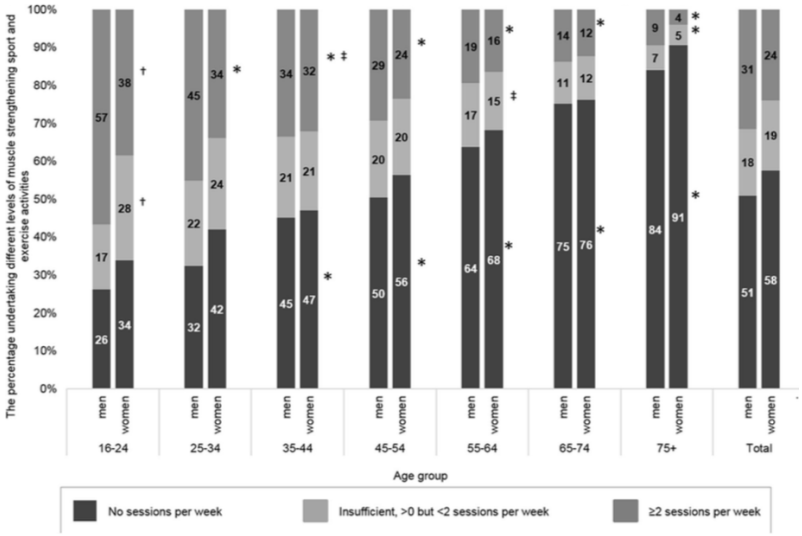


Figure 3. Levels of muscle strengthening sport and exercise activities, by age group and gender (2012-2014). Reprinted from "The forgotten guidelines: cross-sectional analysis of participation in muscle strengthening and balance & co-ordination activities by adults and older adults in Scotland" by Strain, Fitzsimons, Kelly, et al. (2016), BMC Public Health, 16(1), 5. Copyright [2016] by the Authors. Reprinted with permission.

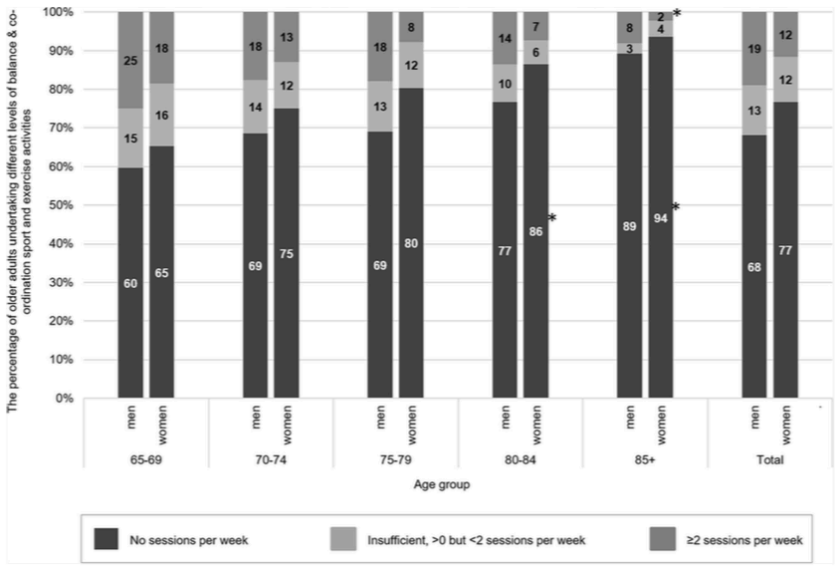


Figure 4. Levels of balance & co-ordination sport and exercise activities, by age group and gender (2012-2014). Reprinted from "The forgotten guidelines: cross-sectional analysis of participation in muscle strengthening and balance & co-ordination activities by adults and older adults in Scotland" by Strain, Fitzsimons, Kelly, et al. (2016), BMC Public Health, 16(1), 5. Copyright [2016] by the Authors. Reprinted with permission.

Despite the benefits of undertaking MS and BC activities, the percentage of the older adult population adhering to these guidelines is low. Studies have explored varied activities to improve MS and BC. The review of reviews by Foster and Armstrong (2018) reported a strong positive effect for activities like resistance training, aerobics and circuit training in improving muscle function and bone health, and a medium effect in improving balance. Yoga is an activity type for which some evidence although with low effect has been found with respect to muscle function and bone health. Three dimensional exercises such as yoga have been found to be effective in improving balance training and falls reduction (Foster & Armstrong, 2018). The sections below explore yoga's potential in improving strength and balance and other physical function and HRQoL measures in older adults.

1.12 Atha Yoga Anushasanam (Now Let us Begin Yoga): Introduction and History

Yoga is an ancient practice that originated in India (Büssing, Khalsa, Michalsen, Sherman, & Telles, 2012). The meaning of the word yoga is "unity" or "oneness", and in spiritual terms the objective of yoga is the merging of the individual and universal consciousness (Saraswati, 2008). Yogic lore has it that the first yogi was the Indian God Shiva (Basavaraddi, 2015). The Yoga Sutras (Atha Yoga Anushasanam, the very first sutra or aphorism was used as the heading for this section), a treatise on yoga composed by the sage Patanjali in 200 - 100 BCE have profoundly influenced modern yoga practice along with texts like the Hatha Yoga Pradipika and Gheranda Samhita (Singh Khalsa, Cohen, McCall, & Telles, 2016). The influence of yoga on the western world started with Swami Vivekananda (1893) (Singh Khalsa et al., 2016), followed by prominent teachers like Swami Shivananda, Shri T.Krishnamacharya, Swami Rama, Sri Aurobindo, Maharshi Mahesh Yogi, Pattabhijois, BKS. Iyengar, Swami Satyananda Sarasvati, whose yoga traditions have continued and grown popular over the years (Basavaraddi, 2015). In the 1960s, yoga rose to popularity with celebrities such as the Beatles learning yoga under the tutelage of Maharshi Mahesh Yogi. Yoga was also associated with psychedelics during this time (Richert & Decloedt, 2018), a perception that still lingers in the minds of some. Yoga may have patriarchal roots and the founders of the popular schools of yoga such as Iyengar yoga, Ashtanga yoga, Bihar School of yoga are all

male (Humberstone & Cutler-Riddick, 2015). However, spurred by media portrayal, yoga is now perceived as female oriented activity in the west. An observation and hypothesis is that the modern format where yoga is taught as a group activity class could be more appealing to women. This may also apply to the east, and in my experience as a teacher, the group classes in India also had a higher proportion of women.

Another notable trend is the narrowing of the purview of yoga to exercises for health and fitness. Postures or asana are only one aspect of the eight limbs (ashtanga: ashta meaning eight, anga meaning limbs) of yoga described by ancient texts (Figure 5). The first few limbs provide guidelines for everyday life, followed by asanas (postures), pranayama (breathing), and progressing to meditative limbs and reaching the final state of union or enlightenment (Singh Khalsa et al., 2016).

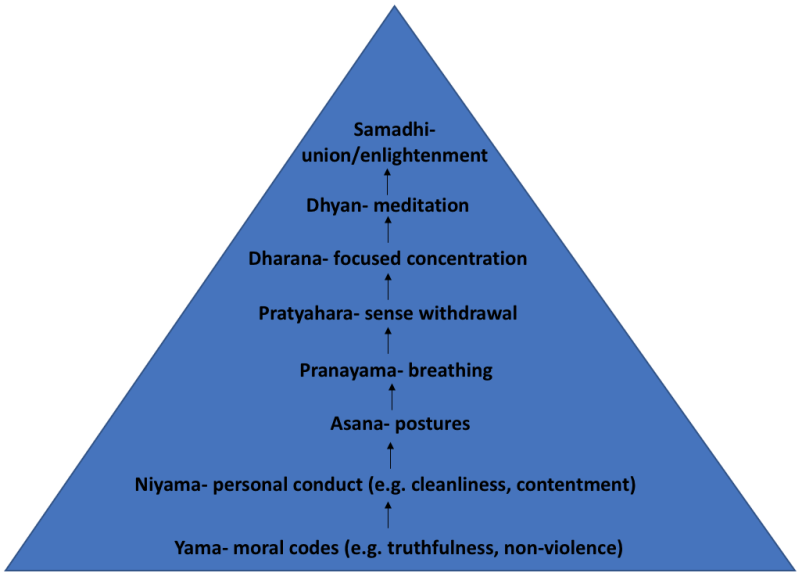


Figure 5. The eight limbs of yoga (Saraswati 2008)

From this background we can see that yoga involves multiple aspects and practices. One could focus on physical and therapeutic aspects, gain mental or psychological benefits, or immerse themselves in spiritual philosophies and practices. Different forms of yoga have been described in ancient texts as alternate routes to achieving the final objectives or the interim steps of yoga (Table 2). These

vast applications have given rise to many different schools or types of yoga (Table 3). Hatha yoga and vinyasa flow are among the most popular types of yoga (Hunsberger, n.d.). Hatha yoga is a form of yoga taught by many schools which focuses on postures, breathing and relaxation. Vinyasa is a form that focuses on movement or transition between postures.

Table 2

Forms of yoga

Forms of yoga	**Explanation**
Ashtanga Yoga	The eight- limbed system outlined by Patanjali forming the basis for all classic approaches to the yoga practice
Hatha Yoga	The initial stages of *ashtanga yoga* practice emphasises right attitudes, asana, breath work and relaxations
Raja Yoga	The meditative stages of *ashtanga yoga* leading from resting the senses to deep states of relaxation, concentration and meditation
Karma Yoga	A yogic path focusing on selflessness and non-attachment. A path that accompanies all other disciplines of practice
Bhakti Yoga	A devotional path often demonstrated through chant, poetry, ritual, pilgrimage and expressions of love for the infinity
Jnana Yoga	A path dedicated to philosophical clarity and self-observation. This approach integrates self-analysis and meditation
Tantra Yoga	A highly integrated holistic path; the umbrella of much of the practice now taught in yoga classes and depicted in yoga texts
Mantra Yoga	An approach emphasising the use of internal *mantric* sounds for mental support and the refinement of awareness
Kundalini Yoga	A path dedicated to arousing dormant spiritual energy (kundalini) and directing it upward along the spinal axis
Laya Yoga	A method contributing to kundalini awakening through the systematic integration of lower energies into higher ones
Svara Yoga	An advanced practice dedicated to the study of *pranic* rhythms and internal paths of energy

Note. Adapted from "The principles and practice of yoga in health care" by Singh Khalsa et al., 2016, p. 26. Copyright 2016 by Handspring Publishing Limited

Table 3

Types and schools of yoga

Types and schools of yoga	**Explanation**
Ashtanga Yoga	A Hatha yoga system taught by Sri K. Pattabhi Jois (1915-2009). It involves synchronizing the breath with a series of postures- producing intense heat, detoxification, a light, strong body and calm mind
Bihar School of Yoga (India)	The Bihar School of Yoga has been the source of many modern publications, translating essential yoga texts. Its teachings and practice focus on the integration of Vedantic, tantric and yogic practice
Bikram Yoga	A system of 26 Hatha yoga postures selected and sequenced by Bikram Choudhury and practiced in a heated room. Heat is supplied in order to soften body tissues and prepare them for purification
Hatha yoga	A large number of yoga studios and schools function without particular school affiliation or branding. The primary form of yoga they teach is hatha yoga, drawing on teachings from a variety of sources and ranging from gentle to challenging
Iyengar yoga	Based on the teachings of Sri B.K.S. Iyengar, this practice style emphasizes precision and alignment. A variety of props make postures accessible. Careful sequencing of postures is cultivated
Kripalu Yoga	Distinguished by an emphasis on bringing awareness to the physical sensations, emotions, and thoughts that arise in practice. Kripalu teachers describe this as "inquiry-based" learning
Kundalini yoga (3HO)	A vigorous practice dedicated to spiritual awakening through the active integration of a wide variety of yoga techniques. Known for integrating posture work with pranayama and mantra
Patanjali yoga	Patanjali yoga promotes the spread of yoga through the work of Swami Ramdev, a leading Indian teacher. The organization has reached most parts of India. It includes a university, a hospital, a training center and a research facility
Power yoga	A vigorous, fitness-based practice of Hatha yoga. Drawn from the teachings of Patabhi Jois, it focuses on flexibility and strength. Class sequences vary and have been imported to a variety of fitness settings
Sivananda yoga	Begins with a traditional, slow-paced, meditative class that helps encourage proper breathing, flexibility, strength, and vitality in the body while calming the mind
Viniyoga	A therapeutic approach that adapts methods of practice according to the unique condition, needs, and interests of each individual. A gentle practice tailored to a student's changing condition
Vinyasa yoga	Traditionally, vinyasa practice is distinguished by its attention to transitions, both within an individual posture and in posture sequences. Vinyasa yoga is now identified with vigorous styles of practice

Note. Adapted from “The principles and practice of yoga in health care” by Singh Khalsa et al., 2016, p. 27 - 29.

1.13 Benefits of Yoga

Benefits of yoga have been described since ancient times and include freedom from disease, steadiness of the body and mind, keeping the body healthy, light and flexible, and achievement of happiness (Sahu, 2017). Studies of varying designs have assessed the benefits of yoga. Data from the US National Health and Nutrition Examination Survey (1999–2006) were linked to the National Death Index to estimate the effects of yoga participation on all-cause mortality (Loprinzi, 2015). The study found that in an unadjusted model, those participating in yoga had a 63% reduced risk of premature all-cause mortality as compared to those not engaging in yoga. However, after adjusting for age, gender and race-ethnicity, no significant association between yoga and all-cause mortality was found. The authors observed that the number of yoga participants may have been too small to possess the statistical power to detect an association. Yoga participation was measured using a survey question on engaging in moderate or vigorous intensity yoga in the last 30 days. While participants were also asked to report the number of times they engaged in yoga and the average duration each time, it is not clear how this was incorporated into the model for estimating the association between yoga participation and all-cause mortality. Hence limitations of the study include considering only a single baseline assessment of yoga and not accounting for regularity of yoga practice.

Several systematic reviews have synthesised the evidence on the physical and psychological benefits of yoga. Some systematic reviews examining the effects of yoga in the management of chronic conditions and improving physical function and psychological measures have been described in this section.

Cramer, Lauche, et al. (2014) examined the effectiveness of yoga on cardiovascular risk factors. The meta-analysis of 44 RCTs with 3,168 participants revealed that compared with usual care or no intervention, yoga improved systolic and diastolic blood pressure, heart rate, respiratory rate, waist circumference, waist-to-hip ratio, total cholesterol, HDL, very low density lipoprotein (VLDL), triglycerides, HbA1c (glycated haemoglobin), and insulin resistance. Authors specifically noted that clinically important improvements were found for systolic

blood pressure, diastolic blood pressure, and heart rate which were reduced by 5.85 mm Hg, 4.12 mm Hg, and by 6.59 beats/min respectively. Yoga also improved HDL when compared with other active exercise interventions. A systematic review and meta-analysis evaluated the effectiveness of yoga in the management of prehypertension and hypertension (Cramer, Haller, et al., 2014). The meta-analysis with 452 hypertensive or prehypertensive patients from seven RCTs found that yoga improved systolic (reduced by 9.65mm Hg) and diastolic blood pressure (reduced by 7.22mm Hg) compared with usual care, indicating large and meaningful improvements.

Yoga has been shown to be beneficial for adults with Type 2 diabetes (Cui et al., 2017). A meta-analysis that included 12 RCTs and 864 patients found that yoga improved fasting blood glucose, HbA1c, postprandial blood glucose, total cholesterol, HDL, and low-density lipoprotein (LDL) compared with diverse controls like walking, usual care, and exercise and lifestyle education.

The effect of yoga in patients with chronic obstructive pulmonary disease (COPD) was examined in a systematic review and meta-analysis conducted by Liu et al. (2014). Five RCTs with 233 patients were included in the meta-analysis, and it was found that yoga training compared with any type of control significantly improved forced expiratory volume in one second (FEV1), FEV1% predicted and six-minute walking distance (6 MWD). The authors concluded that yoga improves lung function and functional exercise capacity in patients with COPD and could be useful as an adjunct pulmonary rehabilitation programme.

In cancer patients, yoga has been shown to improve physical and psychosocial symptoms (Buffart et al., 2012). Thirteen RCTs were included in the review, of which 12 involved breast cancer patients. Results from the meta-analysis revealed that participation in yoga interventions lead to significant large reductions in distress (ES (Cohen's d) = −0.75), anxiety (ES = −0.77), and depression (ES = −0.69), moderate reductions in fatigue (ES = −0.51), moderate increases in general quality of

life (E = 0.37) , emotional function (ES = 0.49) and social function (ES = 0.33), and a small increase in functional well-being (ES = 0.31).

Yoga has also been shown to be effective in the management of lower back pain (Cramer, Lauche, Haller, & Dobos, 2013). In a meta-analysis including 967 chronic lower back pain patients from 10 RCTS, strong evidence was found for short-term effectiveness of yoga in improving pain, and back-specific disability. With respect to long-term effects, strong evidence was found for the improvement of pain and moderate evidence for the improvement of back-specific disability.

Thirty RCTs with 2,173 participants were included in a systematic review and meta-analysis of the effects of yoga on weight-related outcomes (Lauche, Langhorst, Lee, Dobos, & Cramer, 2016). A significant effect was found for waist-hip ratio when comparing yoga and usual care (SMD = − 1.00), but no effects were found for weight, BMI, body fat percentage or waist circumference. In a subgroup of overweight/obese participants, significant effects were found for BMI (SMD = -0.99) relative to usual care. Jeter, Nkodo, Moonaz, and Dagnelie (2014) conducted a systematic review of yoga for balance in a healthy population. 15 trials with varied study designs were included. Positive significant results for at least one balance outcome was found in 11 studies, and the authors concluded that yoga may have an overall positive effect in improving balance in a healthy population.

With respect to psychological parameters, although not many meta-analysis reporting the effects of yoga are available, several systematic reviews report that yoga is a promising intervention for improving mental health outcomes (Sharma, 2014). A systematic review of the effects of yoga on biological measures related to stress (Pascoe & Bauer, 2015) reported that the 25 included RCTs provided preliminary evidence that yoga is associated with biological changes including cortisol levels, SNS (Sympathetic Nervous System) activation, decreased stress and negative affect.

In a systematic review of RCTs evaluating yoga in persons with depression (Cramer, Lauche, Langhorst, & Dobos, 2013a), moderate evidence for short-term beneficial effects of yoga compared to usual care was found for severity of depression. Another systematic review of the efficacy of yoga in the treatment of selected major psychiatric disorders included 16 RCTs (Balasubramaniam, Telles, & Doraiswamy, 2013). The review found some evidence that yoga is beneficial in the management of depression and schizophrenia, and low quality evidence for the effectiveness of yoga in improving sleep complaints.

Yoga has been found to be effective in improving CVD risk profiles and management of chronic diseases and conditions like Type 2 diabetes, COPD, cancer and lower back pain. Evidence also shows that yoga can improve several physical function and psychological parameters.

1.14 Benefits of Yoga for Older Adults

Five systematic reviews (published since 2012) and one critical review (2011) have assimilated the benefits of yoga in older adults. Youkhana, Dean, Wolff, Sherrington, and Tiedemann (2016) conducted a systematic review and meta-analysis to evaluate the effects of yoga on balance and physical mobility outcomes in people aged 60 and over. They found that yoga interventions had a small effect on balance performance (ES (Hedges' g) = 0.4), and a medium effect on physical mobility (ES = 0.5). J. L. Barrows and Fleury (2015) reviewed the effect of yoga in promoting cardiovascular health in older adults. With a total of just 9 RCTs included in the review, some preliminary evidence for improvements in blood pressure, body composition, blood lipids, and blood glucose in both healthy older adults and those with chronic health conditions were reported. A small number of studies reported improvements in endurance, strength, flexibility, balance, mobility, gait speed, and psychological benefits including mood, anxiety, depression, and quality of life.

The effect of yoga on physical fitness was examined by a critical review (Roland, Jakobi, & Jones, 2011) which included 10 studies, 5 of which were RCTs and 5 used a single-group pre–post design. Preliminary evidence for improvements in gait, balance, flexibility, lower body strength, and weight loss was reported. Patel,

Newstead, and Ferrer (2012) reviewed the effects of yoga on physical functioning and HRQoL in older adults. Their review included all RCT published in English during the time period 1950 to November 2010. The meta-analysis results concluded that yoga improves physical (ES (SMD) = 0.65) and mental health status (ES = 0.66), depression (ES = -0.57) and aerobic fitness (ES = 0.54).

A recent systematic review and meta-analysis by Tulloch, Bombell, Dean, and Tiedemann (2018) assessed the impact of yoga on HRQoL and mental wellbeing in adults aged 60 and over. Twelve RCTs were included and the review observed that yoga had a medium effect on HRQoL (ES (Hedges' g) = 0.51), and a small effect on mental wellbeing (ES = 0.38). A systematic review of the effects of yoga on depression and quality of sleep in older adults was conducted in China (Wang, Chang, & Lin, 2014). Although the review has been published in Chinese, from the English translated abstract we can infer that yoga significantly reduced depressive symptoms and improved quality of sleep.

No systematic review on the effects of yoga on cognitive function was identified. However, some RCTs have demonstrated that yoga improves several domains of cognitive, as well as executive function in older adults (Gothe, Kramer, & McAuley, 2014; Hariprasad, Koparde, et al., 2013).

1.15 Limitations in Yoga Research

The findings presented above provide consistent evidence that yoga has numerous benefits in improving physiological and psychological outcomes in older adults. However, the underlying evidence base has a number of limitations. While some limitations stem from the methodology adopted by studies, others are due to the nature of yoga such as variation in styles, forms and a lack of standardisation of postures.

Several reviews cited above reported low methodological quality of RCTs with high risk of bias scores (Cramer, Haller, et al., 2014; Cramer, Lauche, et al., 2014). Insufficient reporting on randomisation procedures (Balasubramaniam et al., 2013;

Cramer, Haller, et al., 2014; Cramer, Lauche, et al., 2014), and whether studies performed intention to treat (ITT) analysis (Buffart et al., 2012; Cramer, Haller, et al., 2014; Youkhana et al., 2016) contributed to high risk of bias. In an RCT, it is important to ensure that every participant has an equal chance of being assigned to intervention or control groups, so as to generate groups which are similar in all respects except for the intervention they receive (Suresh, 2011). Generating a random sequence (random sequence generation), and adopting methods to ensure that the intervention allocation cannot be foreseen before or during enrolment would help limit selection bias (Higgins & Altman, 2008). Selection bias hampers the attribution of changes in outcomes to the intervention, as effects may be influenced by differences in participant characteristics (Suresh, 2011). Lack of reporting on random sequence generation and allocation concealment make it difficult to interpret and draw conclusions on the accuracy of findings. ITT analysis addresses the issues of non-compliance and missing outcomes in a RCT (Gupta, 2011). The analysis ignores non-compliance, and withdrawals to include every subject in the group to which they were randomised. ITT analysis has several advantages and is recommended by the CONSORT (Consolidated Standards of Reporting Trials) statement (Moher, Schulz, & Altman, 2001) to improve the quality of reporting on RCTs. Non-compliance or participant dropout can be viewed as a response to treatment. ITT analysis considers this practical scenario and generates an unbiased estimate of treatment effects (Gupta, 2011). The analysis limits type 1 errors and improves generalisability; it also preserves sample size, and prevents reduction of statistical power due to dropouts (Gupta, 2011).

While participants cannot be blinded in a yoga RCT, lack of blinding of assessors was mentioned in several reviews (Barrows & Fleury, 2015; Cramer, Lauche, et al., 2014; Youkhana et al., 2016). Lack of blinding of assessors can lead to detection bias, where participant assignment affects the process of outcome assessment (Boutron et al., 2007). Not being blinded to intervention assignment, could lead to biased outcome measurement, and influence the choice of analytical strategies and methods (Boutron et al., 2007). The CONSORT statement for randomized trials of nonpharmacologic treatments (Boutron, Altman, Moher, Schulz,

& Ravaud, 2017) acknowledges difficulties in blinding, and recommends that if blinding of participants is not possible in a RCT, attempts must be made to limit bias such as collection of data by an independent researcher, along with rigorous reporting.

Small sample sizes are another limitation within yoga research, and the small number of studies measuring each outcome rendered it difficult to conduct meta-analyses and subgroup analyses to establish the effects of yoga in some reviews (Balasubramaniam et al., 2013; Buffart et al., 2012; Cramer, Lauche, Haller, et al., 2013; Liu et al., 2014; Pascoe & Bauer, 2015). Reviews have reported high heterogeneity stemming from variability in study population, measurement methods, study protocols, types of yoga, duration and frequency of interventions (Cramer, Haller, et al., 2014; Cramer, Lauche, et al., 2014; Cui et al., 2017; Liu et al., 2014; Patel et al., 2012). Most studies only reported shorter-term effects, and evidence on the long-term effects of yoga is scanty (Balasubramaniam et al., 2013; Cramer, Lauche, et al., 2014; Cramer, Lauche, Langhorst, et al., 2013a). Lack of theory underpinning interventions is another limitation in yoga research (Barrows & Fleury, 2017). Theory provides an understanding of the problem and the mechanisms that would lead to the realisation of favourable outcomes, and helps identify interventions with the potential to address the problem (Barrows & Fleury, 2017). The use of theoretical frameworks to guide intervention development would shift focus to the underlying change processes rather than purely on the outcomes (Barrows & Fleury, 2017).

Another factor that complicates research in this area is the nature of yoga, with different aspects, objectives, types, schools, philosophies, postures and techniques which are not easy to standardise. This could make it problematic to replicate interventions, determine dose-response relationships, and translate yoga to a precise exercise prescription. It is thus important that intervention details are meticulously reported, so that there is clarity on the intervention elements and the intervention effects (Hoffmann et al., 2014). Lack of reporting on adverse events, adherence to sessions, and intervention details including postures are other issues in yoga-related

research (Buffart et al., 2012; Cramer, Lauche, Langhorst, et al., 2013a; Pascoe & Bauer, 2015; Patel et al., 2012).

1.16 Prevalence of yoga

The percentage of the Scottish population participating in yoga and pilates has increased from three percent in 2014 to five percent in 2016 (Table 4). This could be attributed to the increased participation among women from five percent in 2014 to eight percent in 2016, with participation among men remaining constant. Among older adults in Scotland (65+ years), yoga participation of men and women over 75 years is negligible. The percentage of women aged 65-74 participating in yoga has increased from 3% (2014) to 6% (2016), while participation rates for men remains low at one percent. Overall, yoga/pilates participation rates decrease with age and the 65+ years age groups have the lowest participation rates. Moreover, since the survey presents data for yoga and pilates combined, these figures may be even lower for just yoga.

Table 4

Participation in yoga/pilates by age and sex in the last four weeks in 2014 and 2016

	Participation in yoga/pilates by age in Scotland (%)							
2014	16-24	25-34	35-44	45-54	55-64	65-74	75+	**Total**
Men	1	3	2	1	1	1	-	2
Women	6	8	6	6	3	3	1	5
All adults	4	6	4	4	2	2	0	3
2016								
Men	3	3	3	2	2	1	0	2
Women	10	11	11	9	8	6	-	8
All adults	7	7	7	6	5	4	0	5

Note. Based on data from the Scottish Health Survey 2014 (Gill, 2015) and Scottish Health Survey 2016 (Currie, 2017)

Prevalence of yoga in the US has been estimated using cross-sectional data from the 2012 National Health Interview Survey with 34,525 adults (Cramer et al., 2016). Lifetime prevalence of yoga (proportion of the population that have practiced yoga at some point in their life up to the time of assessment) was found to be 13.2%, and 12-month prevalence (proportion of the population that have practiced yoga in

the past 12 months) was 8.9%. Lifetime yoga practitioners were more likely to be female, younger, non-Hispanic white and living in the West. Higher education, higher personal income, and better health status was also associated with lifetime yoga participation. Ding and Stamatakis (2014) analysed Health Survey for England data and found that prevalence of yoga practice (in the last 4 weeks) was 0.46% in 1997-1999, 0.94% in 2003-2004, and 1.11% in 2006-2008. Yoga participants in England were more likely to be female, degree educated, and of non-manual social class. They were also more likely to have a lower BMI, better self-rated general health, an inactive occupation, and higher levels of MVPA.

The Scottish (Currie, 2017; Gill, 2015) and England data (Ding & Stamatakis, 2014) for prevalence of yoga assessed yoga practice in the last 4 weeks and are therefore broadly comparable. Since the data for Scotland is from a later time period, it seems logical that prevalence is higher given the increasing trends in yoga participation rates in England and Scotland. Another reason for the higher prevalence data in Scotland could be because yoga and pilates were grouped together. Yoga prevalence in the US (Cramer et al., 2016) is much higher that the England and Scottish data, as lifetime and 12-month prevalence of yoga was assessed in the US prevalence study.

1.17 The Problem and Yoga as a Proposed Solution

The 65+ age group forms 19% of Scotland's population (National Records of Scotland, 2018). Scotland's population is ageing with the biggest increase over the last decade (2007-2017) occurring in the 65-74 age group (23%), followed by the 75+ age group (16%) (National Records of Scotland, 2018). The projected growth-rate for the 65-74 years and 75+ years age groups are 17% and 79% respectively by 2041(National Records of Scotland, 2017). As discussed in sections 1.10 and 1.11, adults aged 65 years and above are the least likely to meet MVPA guidelines in Scotland, and a very small proportion meet the MS and BC guidelines. This population with the maximum projected growth rate and lowest PA levels has been identified by the Sottish government as a high priority group (Scottish Government, 2018) for whom targeted interventions need to be developed.

Yoga is an intervention that is found to have numerous health benefits (section 1.13). Systematic reviews have provided evidence to show that yoga improves a host of physical and psychological outcomes in older adults (section 1.14). Reviews have also provided preliminary evidence indicating that yoga has the potential to improve strength and balance in older adults (section 1.14). Despite the benefits of yoga, only a very small proportion of Scottish older adults participate in yoga (Table 4). Yoga as an intervention to increase adherence to MS and BC recommendations in Scotland has been explored in this PhD, which seeks to understand the barriers to yoga participation, and make recommendations to address issues and promote yoga in this population.

1.18 PhD Objectives

The main objective of this PhD is to develop a yoga intervention that is appealing acceptable and appropriate for older adults in Scotland, that would improve physical function and HRQoL. The project also aims to recommend strategies to encourage yoga participation.

Chapter 2. Methodology

This chapter outlines the broad methodology adopted in this thesis. First a logic model is used to examine programme assumptions in order to identify gaps in literature and propose strategies to address them. The next section aimed at understanding the theoretical underpinnings of the yoga programme under development. Behavioural theories were reviewed and critiqued. Programme theory and theory of change models were discussed as frameworks to understand how the programme would work to achieve the desired objectives. An initial theory of change model is presented, and the methodology to expand and refine the model discussed. Finally, the stages of the PhD and the studies that were undertaken at each stage are presented.

2.1 A Logic Model to Understand Underpinning Evidence and Identify Gaps

The logic model is a tool used to visually represent the relationships among the resources, activities and anticipated changes or results for a particular programme (W.K. Kellogg Foundation, 2006). At a basic level, it specifies how the programme is expected to work, describing the sequence of activities, and how they are linked to the expected results. Logic models can be used for many purposes such as programme design and planning, implementation, evaluation and reporting. During the initial stages of the PhD, a logic model was developed to identify key research gaps and priorities, and activities that would need to be undertaken to address these gaps and achieve the objectives of the PhD. The W.K. Kellogg Foundation Logic Model Development Guide (2006) describes three main types of logic models:
a) Theory approach models: Theory is defined as a set of beliefs or hypothesis upon which the programme plan is built (Weiss, 1998). Theory approach models examine the theory of change that has influenced the design and plan for the programme. The model links theoretical ideas together to explain underlying programme assumptions (W.K. Kellogg Foundation, 2006).

b) Outcomes approach models: The focus of these models is connecting the resources and/or activities with the desired results. These models are also based on

theory of change, but do not emphasise this aspect. Instead, the programme's intended results are of prime importance.

c) Activities approach models: These models focus on implementation aspects. The planned activities are linked together to form a process map of programme implementation. These programmes are useful during the stages of programme monitoring.

The theory approach model centres around the problem or issue and the reasons for proposing the solutions or strategies. Since the theory approach model is appropriate at the conceptualisation stage of an intervention, this has been used to examine broad programme assumptions and identify gaps. The process involved considering the main elements associated with intervention design including the study population, activities and setting (Blamey, MacMillan, Fitzsimons, Shaw, & Mutrie, 2013). Through this process, gaps in the literature and corresponding activities required to address these gaps were identified. This exercise helped determine the focus and structure of the PhD.

A logic model can have different visual representations, and elements of a typical logic model include inputs (resources), activities, output (direct results of the activities), intermediate outcomes (changes in attitudes and behaviour resulting from activities) and impact or final outcomes (changes at an organisation or community level or longer term changes) (W.K. Kellogg Foundation, 2006). The model could also include the programme assumptions. This has been adapted, and the elements of the logic model for this PhD are assumptions/theoretical considerations, gaps, PhD activities, outputs, and ultimate outcomes. The logic model is presented in Figure 6 and the elements of the model are described under two sections: (i) Examining the assumptions of the programme (section 2.1.1) and (ii) Identifying and addressing gaps in literature (section 2.1.2).

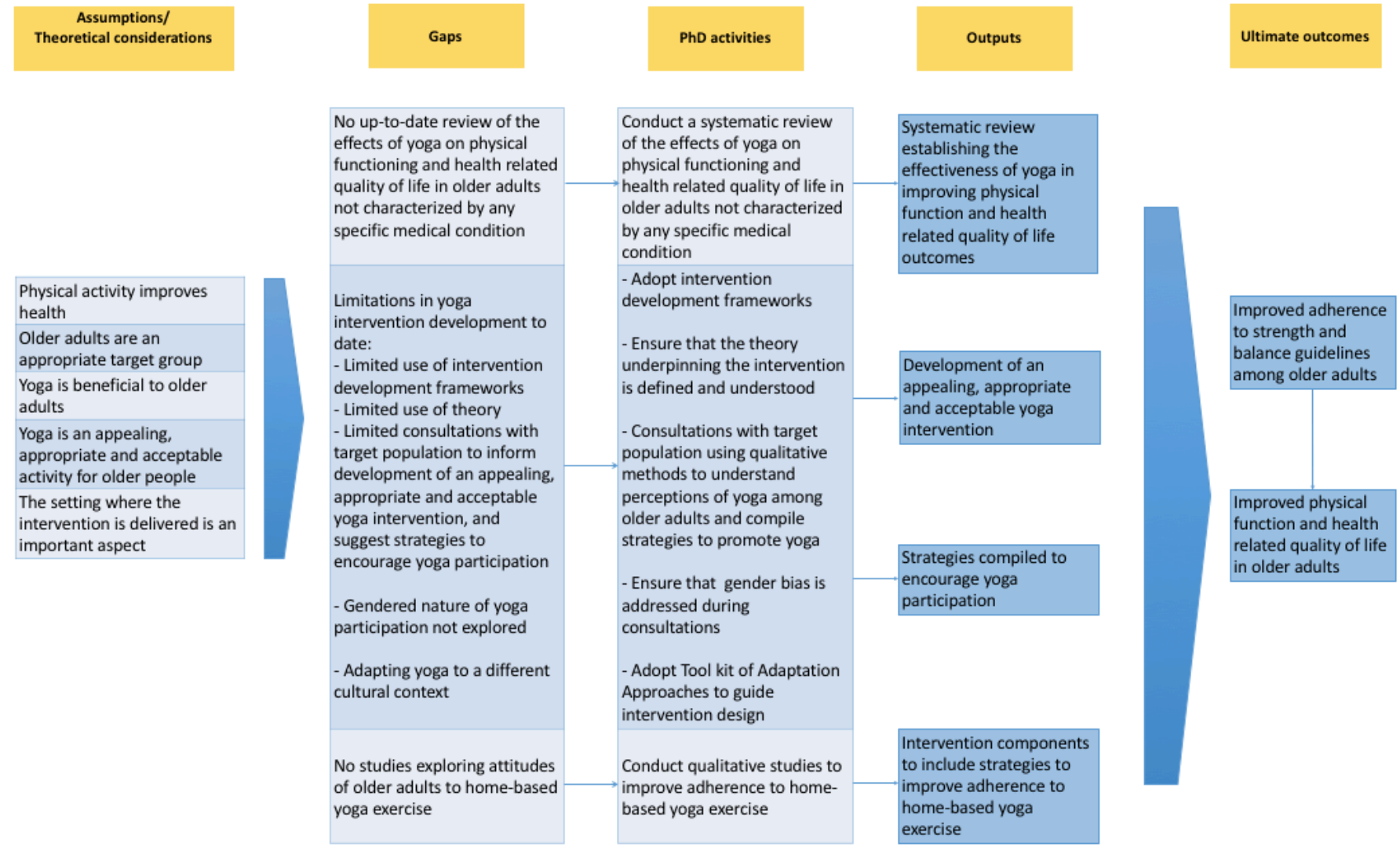


Figure 6. A logic model to examine programme assumptions, identify gaps and activities

2.1.1 Examining the assumptions of the programme. Within the model, the following assumptions were scrutinized -

a. Physical activity improves health: addressed in sections 1.6, 1.8 and 1.9

b. Older adults are an appropriate target group: addressed in sections 1.2, and 1.17

c. Yoga is beneficial to older adults: addressed in section 1.14

d. Yoga is an appealing, acceptable, appropriate and feasible activity for older people

e. The setting where the intervention is delivered is an important aspect

The evidence to support the first three assumptions is presented in the initial sections of this chapter. The last two elements are described below-

2.1.1.1 Yoga is an appealing, appropriate and acceptable activity for older adults

2.1.1.1.1 Examining yoga intervention development undertaken so far. Before defining the terms appealing, acceptable and appropriate, and discussing yoga literature that has addressed them, a review of studies that have described the process of developing a yoga intervention for older adults was undertaken. Four studies have reported in appropriate detail, intervention development activities undertaken to design a yoga programme for older adults. Two of the studies were published during the time period that this PhD research was being conducted.

(i) Intervention development 1(Barrows & Fleury, 2017): A theory based yoga intervention was developed for older adults at risk of CVD. The Yoga for Heart programme was developed by the lead researcher (a registered nurse and a certified yoga instructor with experience in working with older adults). The frequency (twice a week), duration (60 minutes) and length (12 weeks) were based on a review of literature. An intervention manual with a standardised protocol would be followed by the instructor, but the goals and concerns of each participant would be addressed. Wellness Motivation Theory was used as a framework for understanding yoga practice for promoting cardiovascular health in older adults. The problem was defined in the study as decreased motivation for PA in older adults due to limited behavioural change processes and social contextual resources. In their proposed model, motivation for health behavioural change can be increased by the development of social contextual resources (social support, and environmental

resources) in interaction with behavioural change processes (such as self-knowledge, motivation appraisal, self-regulation).

Critical inputs in the programme included (i) Empowering education: The yoga programme would seek to incorporate activities to empower education, where participants are not passive recipients of knowledge. Time would be provided during the yoga session for participants to engage in group discussion regarding the benefits of yoga, advantages of progressing gradually and following an individualised plan, strategies to maintain PA and integrate behavioural change into daily life (ii) Strengthen social networks: in the yoga programme, social network support would take the form of small group yoga sessions conducted by the instructor, where participants would be encouraged bring a friend or family member. (iii) Motivational support: this would be provided by incorporating group discussions where personal goals, barriers and challenges to physical activity, problem-solving strategies to sustain motivation for behavioural change would be discussed. Sharing future plans and celebrating achievements is another element.

Contextual factors that influenced implementation, mediators (behavioural change processes and social contextual resources) and outcomes were also identified. These included (i) Participant characteristics such as health status and past experience with PA and/or yoga (ii) Characteristics of the interventionist were acknowledged as important, and the programme would be delivered by a registered nurse and a certified yoga instructor who had experience working with older adults. The interventionist would adopt a friendly and non-judgemental attitude and communicate information clearly. (iii) Delivery setting: The yoga programme will be conducted in a community-based yoga studio with the appropriate lighting, ventilation, and a quiet atmosphere. The proposed yoga programme was developed based on this framework and authors aim to carry out a pilot evaluation in the future.

(ii) Intervention development 2 (Smith, Mross, & Christopher, 2017): In the process of developing a yoga programme for falls reduction in older adults, Smith et al. (2017) conducted a literature search and identified three poses (chair, tree pose

and high lunge) that would target falls reduction by strengthening ankle dorsiflexion, psoas, gastrocnemius, tibialis anterior and soleus muscles. Intervention development then took the form of a single-arm pilot and feasibility study conducted in rural Wisconsin, USA with the following objectives: (i) developing a working relationships with community organisations and enrolling their assistance in recruitment and execution of the project (ii) Recruitment: recruiting at least 20 participants (iii) Acceptability among participants: as measured by drop-out rates (iv) Feasibility of evaluation methods: as measured by evaluation completion rates (v) Safety of the intervention: as assessed by number of adverse events. The intervention consisted of 50–60 min yoga classes for 8 weeks. The intervention also included home yoga practice of the 3 poses (chair, tree pose and high or crescent lunge) for 10-mins on 3 days per week. Class structure included 5 min of community sharing, 5 min of centring, 10 min of review of the home yoga practice, 35 min of other poses and breathing, and 5 min of relaxation. Modifications were provided using props like chairs or straps, and floor exercises were avoided due to concerns around mobility and safety. Evaluations included self report of number of falls in the previous one month, six months and one year, and the Tinetti Falls Efficacy Scale. Physical evaluations included the 30 Second Chair Stand test, and the FICSIT-4 (Frailty and Injuries: Cooperative Studies of Intervention Techniques) administered by a blinded trained physical therapist.

Results showed that recruitment, acceptability, feasibility of evaluation methods and safety objectives were met by the programme. A convenience sample of 20 adults were recruited with only one person dropping out before the programme started. Nineteen participants (95%) completed the follow up evaluation. No other serious adverse events occurred. Participants reported four falls in the month before the intervention and one fall the month before the post-intervention evaluation. No significant change was found for the Tinetti falls efficacy scale scores post intervention. A non-significant improvement in FICSIT-4 and mean scores for 30 Second Chair Stand test was found. Successful collaborations were established with a rural hospital and the Aging and Disability Resource Center. Authors concluded the programme designed to reduce falls was feasible and acceptable to participants.

(iii) Intervention development 3 (Hariprasad, Varambally, et al., 2013): Hariprasad, Varambally, et al.(2013) reported on the development, validation and testing of a yoga intervention for older adults with or without mild cognitive impairment. The development process included the systematic review of traditional and contemporary yoga texts authored by yoga gurus and experts, from which suitable postures were selected. These were refined by introducing modifications and using props where required. The yoga programme consisted of the following elements: warm-up exercises, physical postures, purification practices, breathing exercises and meditation.

The validation process as described by authors involved sending three case vignettes of elderly with symptoms of MCI and the text of the yoga module to 15 experts on yoga. Ten experts completed the questionnaire, rating the usefulness of each element on a scale of 1-5 (1-Not at all, 2-A little, 3-Moderately, 4-Very much and 5-Extremely). Elements that scored three or more from at least 80% of the experts were included in the final module. Qualitative data was also collected on appropriateness of yogic practice, duration of each session, yoga training, sequence of yoga practices and overall yoga module. Experts agreed on the usefulness and appropriateness of most elements of the programme, and some modifications were suggested.

Ten older adult participants from Bangalore, India then tested the feasibility of the programme, of which nine met the criteria for mild cognitive impairment. The duration of the programme was 1 hour, conducted daily for one month. At the end of the programme, the yoga instructor rated the participants' performance during the supervised yoga sessions using a yoga performance assessment tool developed for the study. Participants' performance was rated on a scale of 0-3 (0-Can't practice at all, 1-Needs assistance throughout the practice, 2-Needs assistance through some steps of the practice, 3-Can practice with ease without assistance of instructor). Participants' ability to complete the entire yoga sequence, remember and complete each step of the yoga practice, co-ordinate breathing with postures, breathe as instructed during breathing exercises and relax during the yogic practices were also given similar ratings. All the participants were able to complete most of the warm-

up, breathing and meditation without difficulty. Three participants experienced difficulty in performing postures seated on the ground. The older adults also found it difficult to remember and complete the entire programme sequence independently.

(iv) Intervention development 4 (Chen, Tseng, Ting, & Huang, 2007): The development and evaluation of the Silver Yoga Programme for older adults consisted of two phases. In Phase 1, Ten experts rated the clarity (relative ability of an individual to understand how to perform a particular posture based on description) and feasibility (whether a particular posture is appropriate and capable of being performed by older adults) of the yoga postures. Clarity and feasibility were rated on a scale from 1 to 4 (1: posture is unclear, hard to understand, extremely inappropriate and should be removed; 2: major revisions should be made to the posture and/or posture description; 3: the posture is satisfactory but needs minor revision and 4: the posture is clear, easy to understand, appropriate, essential and should not be omitted). The programme consisted of four parts including warm-up, hatha yoga postures, relaxation and guided-imagery meditation.

In Phase 2, 14 women participants from a senior activity centre in Taiwan tested the programme, which was delivered three times per week, 70 minutes per session for one month. Participants evaluated the postures based on the criteria of difficulty, acceptability, feasibility and helpfulness. Participants also commented on five open-ended questions: (1) how do you feel after one month of Silver Yoga practice? (2) how many times per week of yoga practice is appropriate? (3) how long per yoga practice session is appropriate? (4) how many people per group are appropriate for practicing yoga? (5) what type of yoga instructor do you prefer for learning yoga? The questions were verbally posed to the participants by the researcher who noted their answers on the evaluation forms. Mean difficulty scores across the four parts of the yoga programme (warm-up, hatha yoga postures, relaxation and guided- imagery meditation) ranged from 0.1 to 2.1(10 being very difficult to perform). Acceptability scores ranged from 8.8 to 9.3 (10 being completely acceptable), feasibility scores ranged from 8.8 to 9.5 (10 being very appropriate) and helpfulness scores ranged from 8.9 to 9.3 (10 being very helpful to their health). Preferred frequency was three times a week and duration was tied

between 70 minutes (n=5) and 60 minutes (n=5). The preferred number of participants in a class was 15-20 people for the majority of participants. No preference for the sex of the instructor was expressed, although 3 participants preferred a middle-aged instructor. The instructor being professionally trained (n=1), considerate (n=1) and patient (n=1) was also preferred.

The development process adopted by the four studies, and the characteristics of the developed programmes have been summarised in Table 5.

Table 5

Summary of processes used in four studies while developing a yoga intervention for older adults

	Intervention development 1	**Intervention development 2**	**Intervention development 3**	**Intervention development 4**
Authors	Barrows and Fleury (2017)	Smith et al. (2017)	Hariprasad, Varambally, et al. (2013)	Chen et al. (2007)
Location	Arizona USA	Rural Wisconsin, USA	Bangalore, India	Taiwan
Development process	1. Programme developed by PI based on Wellness Motivation Theory 2. Frequency, duration, length decided based on a review of literature	1. Literature search identified 3 important poses for building strength (chair, tree and high lunge) 2. Single-arm pilot and feasibility study	1. Systematic review of traditional and contemporary yoga texts authored by yoga experts, from which suitable postures were chosen 2. 10 yoga experts rated the usefulness of each element of the programme on a scale of 1-5 and some qualitative data collected on appropriateness of yoga practice 3. 10 older adults tested feasibility of the programme and an instructor rated participant's performance on a scale of 1-3	1. 10 experts rated the clarity (ability to understand how to perform a particular posture, based on the description) and feasibility (whether a particular posture is appropriate and capable of being performed by older adults) 2. 14 older women tested the feasibility of the programme and rated it on difficulty, acceptability, feasibility and helpfulness. Participants also commented on 5 open ended questions.
Programme structure	Opening or centring exercise (5mins), physical postures (40 mins), closing exercise with relaxation and meditation (5 mins), group discussion (10 minutes)	5 min of community sharing, 5 min of centring, 10 min of review of the home yoga practice, 35 min of other poses and breathing, and 5 min of relaxation	Warm-up exercises, physical postures, purification practices, breathing exercises and meditation	Warm-up, hatha yoga postures, relaxation and guided- imagery meditation
Frequency, duration and length of intervention	Frequency: twice a week, duration: 60 minutes, length: 12 weeks	Frequency: thrice a week, duration: 60 minutes, length: 8 weeks	Frequency: daily, duration: 60 minutes, length: 1 month	Frequency: thrice a week, duration: 70 minutes, length (of testing): 4 weeks

2.1.1.1.2 Exploring appeal, appropriateness and acceptability of yoga interventions. For an intervention to be effective, it is important that it is appealing, appropriate and acceptable for the intended population (Blamey et al., 2013). The terms appealing, appropriate and acceptable are explored below, and given the absence of clear definitions in the context of physical activity, definitions for this PhD project have been developed.

The dictionary definition of appealing is "attractive or interesting" (Oxford Dictionaries, n.d.-a). Yoga studies have mainly reported post-intervention views on whether they found the yoga programme to be appealing. Appeal has been assessed and inferred from enjoyment ratings ascribed to yoga programmes by participants. For example, Cheung, Wyman, Resnick, and Savik (2014) conducted an RCT to assess the effectiveness of a yoga intervention in women with knee osteoarthritis. The study reported that the participants found the yoga programme enjoyable with an average enjoyment rating of 9/10. All participants in the study expressed that they would recommend the yoga programme to others with osteoarthritis. Appeal has also been judged from qualitative responses of yoga participants. In a recent yoga RCT by Tew, Howsam, Hardy, and Bissell (2017), older adult participants assigned to a yoga intervention also completed an exit interview. Eighteen of the twenty participants (90%) reported that they enjoyed the programme. Older adult participants in the RCT conducted by Morris (2008) mentioned in qualitative interviews that they enjoyed and loved doing yoga.

The definition for appropriate is "suitable or proper" (Oxford Dictionaries, n.d.-b). While describing appropriateness or suitability of interventions for a population, studies have alluded to beneficial effects (Jakicic et al., 2001), safety and reduced risk of injury (Blamey et al., 2013), and appropriateness from a cultural perspective (Davidson et al., 2013). For this PhD project, the appropriateness of an intervention for a specific population will be defined in terms of (a) having beneficial effects and (b) safety and (c) cultural appropriateness.

The beneficial effects of yoga in older adults have been examined in an earlier

section (1.14). Whether an intervention is safe can be judged from the number of adverse events such as injuries that occurred during the course of a yoga programme. Injuries and adverse events related to yoga practice from epidemiological studies have previously been systematically reviewed (Cramer, Ostermann, & Dobos, 2017). Findings from nine observational studies with 9,129 yoga practitioners and 9,903 non-yoga practitioners were that the incidence of adverse events occurring during a yoga class for general practitioners was 22.7%. Twelve-month prevalence (proportion of the population experiencing adverse events during a yoga class in the past 12 months) was 4.6%, and life time prevalence (proportion of the population experiencing adverse events during a yoga class at some point in their life up to the time of assessment) ranged from 21.3% to 61.8%. Prevalence of serious adverse events was 1.9%. Authors observed that most adverse events could be described as mild and transient, and advised that while people should continue practicing yoga, those with medical conditions should consult their physicians before practicing yoga.

Cramer et al. (2015) conducted meta-analyses of the frequency of adverse events in yoga RCTS comparing yoga with three groups (usual care/no treatment, exercise, and psychological/educational interventions). No significant difference was found when comparing yoga to usual care/no treatment and exercise groups with respect to frequency of serious or non-serious adverse events. However, compared to psychological or educational interventions, more non-serious adverse events occurred in the yoga groups, which is expected given the non-active nature of controls. There was no significant difference in the frequency of serious adverse events between the two groups.

Cramer, Krucoff, and Dobos (2013) systematically reviewed adverse events associated with yoga from case reports and case series. They recommended that yoga should be practiced under the guidance of a qualified instructor. They advised that beginners should avoid extreme practices. As with the previous systematic reviews (Cramer et al., 2017; Cramer et al., 2015), they recommended that those with medical conditions should work with their physicians and yoga instructors to adapt the practice to suit them.

One definition of acceptable is “able to be tolerated or allowed” (Oxford Dictionaries, n.d.-c). While the definition is close to appropriateness, acceptability of a yoga intervention can be thought of as how difficult participants found the intervention, and whether they approved of the content and structure. Cheung et al. (2014) in their RCT assessing the effectiveness of yoga in women with knee osteoarthritis, obtained data on participants’ perceived difficulty levels. The average difficulty level was 4/10 (where 10 is extremely difficult). Acceptability was also assessed in the intervention development studies described in section 2.1.1.1.1 (Chen et al., 2007; Smith et al., 2017). Acceptability was assessed based on dropout rates in the study by (Smith et al., 2017). The intervention was found to be acceptable in the study with just one dropout in 20 participants. Chen et al. (2007) procured feedback from 14 women who participated in a yoga intervention for one month. Participants rated the difficulty and acceptability of yoga postures. Mean acceptability scores across the four parts of the yoga programme (warm-up, hatha yoga postures, relaxation and guided- imagery meditation) ranged from 8.8 to 9.3 (10 being completely acceptable), difficulty scores ranged from 0.1 to 2.1 (10 being very difficult to perform), and feasibility (whether a particular posture is appropriate and capable of being performed by older adults) scores ranged from 8.8 to 9.5 (10 being very appropriate). A similar evaluation was conducted by Chen, Wang, Li and Chen (2011) who compared acceptability, difficulty and feasibility ratings of yoga exercises among 64 community dwelling and 33 institutional older adults. Mean acceptability scores across the 4 phases of the yoga programme (warm-up, hatha yoga postures, relaxation and guided-imagery meditation) ranged from 8.42 to 9.70 (10 being completely acceptable), difficulty scores ranged from 0.2 to 1.97 (10 being very difficult to perform), and feasibility scores ranged from 8.58 to 9.69 (10 being very appropriate). Although the definitions of acceptable and appropriate used in the study by Chen et al. (2007) are not clear and differ from the those used in this PhD project, some inferences on these facets can be drawn.

For this PhD, appeal will be interpreted as attractive or interesting, acceptability as approval of content, structure and difficulty levels, and, appropriate as beneficial, safe and culturally suitable.

2.1.1.2 Intervention setting is an important aspect. The setting is an intervention characteristic that describes where the intervention will be delivered (e.g. home-based, leisure-centre based, primary care, workplace) (Greaves et al., 2011). The main settings typically considered for a yoga intervention for older adults are home-based and class-based (group) delivery.

2.1.1.2.1 Potential of home-based sessions as a setting to deliver physical activity interventions. Whether the intervention is home-based or class-based may affect adherence and outcome measures (Carmeli, Sheklow, & Coleman, 2006; McCarthy et al., 2004). A systematic review compared the effects of home-based exercise and supervised centre-based cardiac rehabilitation on a number of physical and psychological outcomes in patients with coronary heart disease (Dalal, Zawada, Jolly, Moxham, & Taylor, 2010). Twelve studies with 1,938 participants were included, and the review found no significant difference between home and centre based rehabilitation for mortality, cardiac events, exercise capacity, modifiable risk factors, or HRQoL. Evidence of higher adherence was also found for home-based participants. Since the population reviewed were patients with coronary heart disease, these finding cannot be generalised to an older adult population, but it does emphasise the potential of home-based exercise. Carmeli et al. (2006) compared a class-based and a home-based exercise programme for improving health and rehabilitation outcomes among older adults who had undergone a hip surgery in Iran. Though both programmes improved physical functioning, the supervised class-based programme was more beneficial than the home-based one. No significant difference was found between the two groups with respect to adherence. Supplementing a home-based programme with an exercise programme that involved attendance at a physiotherapy department was found to be more effective in improving locomotor function and reducing walking pain than just a home-based programme among patients with knee osteoarthritis (McCarthy et al., 2004). The effectiveness of home-based sessions compared to class-based is not very clear from the evidence, however, there may be some advantages to home-based delivery among older adults which could promote adherence. Cost, lack of access to recreational facilities (Baert, Gorus, Mets, Geerts, & Bautmans, 2011) and environmental factors such as lack of access to

public transport (Moran et al., 2014) have been identified as barriers to physical activity, which can be addressed by home-based delivery.

2.1.1.2.2 Home-based yoga interventions. No systematic reviews establishing the effectiveness of home-based yoga interventions were identified, therefore findings from individual studies are summarised below. Smedley (2000) evaluated the effectiveness of a 10-week home-based yoga programme in improving flexibility in women aged 45-75 years. Participants were given a written description of the postures and a video of the exercises. The investigator also demonstrated the postures to each participant at the start of the programme. In this study, the yoga intervention did not significantly enhance flexibility. Though adherence was not reported, low adherence was one hypothesised reason to explain why the intervention did not work. Many yoga studies in older adults involved class-based yoga sessions and strongly encouraged participants to practice yoga at home as well (Cheung et al., 2014; Oken et al., 2006). In the studies by Cheung et al. (2014) and Oken et al. (2006), participants were given hand-outs or illustrated booklets to aid their independent practice. Daily home practice was suggested, and occurred on 64% of the days in the Oken et al. (2006) intervention. Participants in the study by Cheung et al. (2014) were instructed to practice yoga at home for 30-minutes on four days a week, in addition to the class-based session (once a week). Only 33% practiced yoga at home as prescribed in the study, but 70% practiced yoga at home on more than 4 days a week (although not for 30 mins as suggested). Moreover, at a 20-week follow up, 74% of participants reported that they continued to practice yoga, reiterating the potential of home-based interventions to promote continued adherence in the long run. Home-based sessions could also help meet the MS and BC recommendations of performing these activities twice a week. The setting of the intervention is therefore an important component, and should be considered during intervention design.

2.1.2 Identifying and addressing gaps in literature

2.1.2.1 Effects of yoga on physical and mental health. Only five systematic reviews have assessed the effects of yoga in older adults. However, these systematic reviews have some limitations. The review by Tulloch et al. (2018) assessed the

impact of yoga in improving HRQoL and mental wellbeing. HRQoL was measured by physical component summary scales, and mental wellbeing was assessed by mental component summary scales from questionnaires like SF-36 (36-Item Short Form Health Survey) and WHOQOL (The World Health Organization Quality of Life). However, HRQoL has been described as a concept encompassing several aspects of overall quality of life that can be clearly shown to affect health (Centers for Disease Control and Prevention, 2016), including anxiety, stress, depression, vitality, social health and sleep (Rejeski & Mihalko, 2001). These aspects of HRQoL were not addressed by the Tulloch review. The only systematic review assessing the effects of yoga on sleep in older adults was published in Chinese (Wang et al., 2014). Patel et al. (2012) reviewed the effects of yoga on physical functioning and HRQoL in older adults. Their review included all RCTs published in English during the time period 1950 to November 2010. Some limitations have been identified in their review. Their search strategy did not include theses and dissertations and only a narrow list of search terms was included in their search methodology. Further, the research question of the review aimed to assess whether yoga improved physical functioning and HRQoL outcomes compared to other physical activity interventions. In their analysis, yoga was compared against a combination of active (e.g. walking, aerobic exercise) and inactive controls (e.g. pamphlets, waitlist controls), making it difficult to judge the efficacy of yoga against each of these distinct groups. Importantly, both the Tulloch and Patel reviews included studies that recruited participants with medical conditions. The yoga programme in these studies may have been designed to address specific symptoms of the disease or condition. Also, the inclusion of participants with various medical conditions could introduce considerable heterogeneity making it difficult to assess and generalise the effects of yoga. Although yoga has been recommended as a MS activity in the national PA guidelines of the UK and US (Department of Health, 2016; United States Department of Health and Human Services, 2008), no meta-analysis has been conducted so far to establish the effects of yoga on MS.

Reviewing the evidence around the effects of yoga revealed several gaps which have been summarised below:

1. No existing systematic reviews and meta-analyses assessing the effects of yoga on several physical function and HRQoL outcomes including MS, social health, and vitality.
2. No review with separate assessments of the effects of yoga compared to active and inactive controls in older adults.
3. No systematic review assessing the effects of yoga in an older adult population not characterised by any specific clinical condition.

A systematic review with meta-analysis (if possible) to address these gaps and limitations of previous reviews was therefore planned to be undertaken as a part of this PhD. This study is essential to establish the evidence base of the effects of yoga in a general older adult population. The findings of the systematic review will also feed into intervention design.

2.1.2.2 Developing an appealing, appropriate and acceptable yoga programme and identifying strategies to encourage yoga participation in older adults in Scotland

2.1.2.2.1 Yoga intervention development. Different processes have been adopted in the development of a yoga programme by the four studies described in section 2.1.1.1.1, and these are summarised in Table 5. Barrows and Fleury (2017) adopted guidelines to incorporate theory within interventions as suggested by Fleury and Sidani (2012), which included (a) accurate conceptualisation of the problem targeted (b) specification of the critical inputs that operationalise the intervention (c) delineation of contextual factors that influence the implementation and outcomes of the intervention (d) understanding of the mechanisms or processes of change. The other three studies (Chen et al., 2007; Hariprasad, Varambally, et al., 2013; Smith et al., 2017) did not adopt a formal intervention development framework. The significance of intervention development frameworks and a description of various framework is presented in section 2.2. Two studies (Barrows & Fleury, 2017; Smith et al., 2017) conducted a literature review and one conducted a systematic review (Hariprasad, Varambally, et al., 2013) to inform intervention development. Two studies (Hariprasad, Varambally, et al., 2013; Smith et al., 2017) used the review to select postures for the programme and one used the review to decide the

frequency, duration and length of the intervention (Barrows & Fleury, 2017). In two studies (Chen et al., 2007; Hariprasad, Varambally, et al., 2013), yoga experts rated the intervention on parameters like clarity, appropriateness and usefulness. Inputs from the target population was limited to older adults testing the intervention in two studies (Chen et al., 2007; Hariprasad, Varambally, et al., 2013), single armed pilot testing (Smith et al., 2017), and a randomised pilot study (planned) (Barrows & Fleury, 2017). Participants rated the intervention and answered five open ended questions in one study (Chen et al., 2007), and in another study the instructor rated the performance of the participants (Hariprasad, Varambally, et al., 2013). In the single armed pilot study (Smith et al., 2017), acceptability of the intervention was reported; assessed by dropout rates and safety of the intervention measured by number of adverse events. This review of literature helped identify some gaps in the processes adopted to develop yoga programmes for older adults:

(i) Limited use of structured intervention development frameworks

(ii) Limited use of theory to inform intervention development

(iii) The intervention development stage is brief, usually skipping ahead to pilot and feasibility testing

(iv) Heavy dependence on "experts", and the target population was seen as recipients of the intervention

(v) Limited consultations with the target population, with their involvement mostly during feasibility and pilot testing

(vi) Rich qualitative data from focus groups or in-depth interviews to understand perceptions and barriers among the target population was not used to inform intervention development

(vii) No evidence based intervention development undertaken in the UK

2.1.2.2.2 Examining appeal, appropriateness and acceptability of yoga programmes.

While some studies have assessed whether the yoga programme is appealing, appropriate and acceptable (section 2.1.1.1.2), this has not been studied in Scotland. Considering the low older adult participation rates in yoga in Scotland (Table 4, (Currie, 2017)), this information is vital while designing a yoga intervention for this population.

Only one yoga RCT with older adult participants has been conducted in the UK (Tew et al., 2017). While the exit interview in this RCT provides information on participants' perceptions of the programme and its benefits, no studies have addressed the perceptions of older adults who have never done yoga, and developed strategies to address barriers.

Yoga originated in India, and we need to ensure that it is modified appropriately so that it palatable to a Scottish audience. Davidson et al. (2013) developed a Tool Kit of Adaptation Approaches that would aid the planning and delivering of behaviour change interventions to ethnic minorities in the UK. The authors noted that the Tool Kit has the potential to be applied to a "wide spectrum of other health topics and population groups" (Davidson et al., 2013, p. 834). The Tool Kit is relevant to the design of this yoga intervention as we are adapting the intervention to a different culture than from where it originated. The Tool Kit consists of a) a forty-six item Typology of Adaptation Approaches b) a Pathway to Adaptation and c) RESET (Relevance, Evidence base, Stages of intervention, Ethnicity, and Trends), a decision tool that provides guidance on which adaptations to employ and when (Davidson et al., 2013). The Typology of Adaptation Approach consists of forty six items that should be considered while conceptualising, implementing and reporting interventions (Davidson et al., 2013). The Pathway to Adaptation is an element of the Tool Kit that tells us which of the forty six items in the Typology of Adaptation Approaches are relevant to each stage of the intervention. For the conceptualisation and planning stages of the intervention, the Pathways to Adaptation prescribes certain relevant items from the typology (Appendix 1). For example, an exploratory phase with the target population is recommended. Based on this, it was decided that consultations with the target population will aid the development of an intervention that is appealing, appropriate, and acceptable for older adults in Scotland. While intervention development was not rigidly based around the Tool Kit, several aspects have been influenced by it as detailed in a later section (2.3).

2.1.2.2.3 Strategies to promote yoga. There is also a lack of studies focusing on developing strategies to encourage yoga participation in an older adult population. Based on

the fact that yoga has been found to be beneficial for older adults, and given the low participation rates in yoga, an important question to address would be how to promote yoga in this population. This has not been explored by research studies.

In summary, the process of identifying gaps emphasised certain aspects that should be prioritised during intervention development:
(i) Adoption of an intervention development framework
(ii) Ensuring that the theory underpinning the intervention is defined and understood
(iii) Consultations with the target population to inform intervention development and compiling strategies to encourage yoga participation in an older adult population
(iv) Use of methods like focus groups to gather rich qualitative data from the target population to inform intervention development
(v) Adopting the Tool Kit of Adaptation Approaches (Davidson et al., 2013) to ensure that the intervention is culturally appropriate

2.1.2.3 Gender. Women are more likely to participate in yoga than men (Cramer et al., 2016; Ding & Stamatakis, 2014), and in Scotland, male participation rates in yoga/pilates are particularly low (Table 4, (Currie, 2017)). The Tool Kit for Adaptation Approaches recommends that gender should be taken into consideration during the conceptualisation stage of the intervention (Appendix 1, (Davidson et al., 2013)). Since the gendered nature of yoga participation has not been examined, planned consultations with the target group aims to explore this gender bias.

2.1.2.4 Setting. The setting of the intervention is especially important in an older adult population (section 2.1.1.2), and this has not been adequately addressed by yoga studies. Studies have used handouts, videos (Cheung et al., 2014; Oken et al., 2006; Smedley, 2000) and multipoint videoconferencing (Selman, McDermott, Donesky, Citron, & Howie-Esquivel, 2015) for home-based classes. The optimal and most comfortable medium for home-based practice in older adults is not known. Strategies to improve adherence in home-based yoga intervention programmes have also not been explored. Exploring home-based sessions as a part of a yoga programme will form an important component of this PhD project. The suggested

consultations with the target population will also aim to gain insights on the medium of delivery of home-based classes (handouts/videos), and strategies to improve adherence to a home-based yoga session among older adults.

2.2 Intervention Development Frameworks

The effectiveness of a public health intervention is greatly influenced by its design, and adopting an intervention development framework to guide the design processes is thought to increase the likelihood of success of the intervention (Wight, Wimbush, Jepson, & Doi, 2016). There are a number of frameworks which can be used to guide intervention development (Craig et al., 2013; Nutbeam & Bauman, 2014; Wight et al., 2016).

The MRC (Medical Research Council) framework for development and evaluation of complex interventions was developed in 2000 (Medical Research Council, 2000) with subsequent updates. An update of this framework will be published in 2019, and the current iteration (Craig et al., 2013) has been used as a key reference in this PhD. The steps in the development and evaluation of complex interventions include development, feasibility or pilot testing, evaluation and implementation (Craig et al., 2013). The MRC framework (Craig et al., 2013) suggests that these steps are not linear or cyclical, but rather inform each other and are constantly revisited (Figure 7). The development phase in the MRC framework (Craig et al., 2013) involves:

(i) Identifying the evidence base: The framework recommended identifying what is known about similar interventions, and undertaking a systematic review if no recent high quality review was available.

(ii) Identifying or developing appropriate theory: Developing a theoretical understanding of the likely process of change is recommended. This included identifying the expected changes and hypothesising how the change will be achieved.

(iii) Modelling process and outcomes: In this step, it is suggested that a series of studies should be conducted before undertaking a full-scale intervention. This is to ensure that a full-scale evaluation is warranted, and to identify weaknesses and refine the intervention.

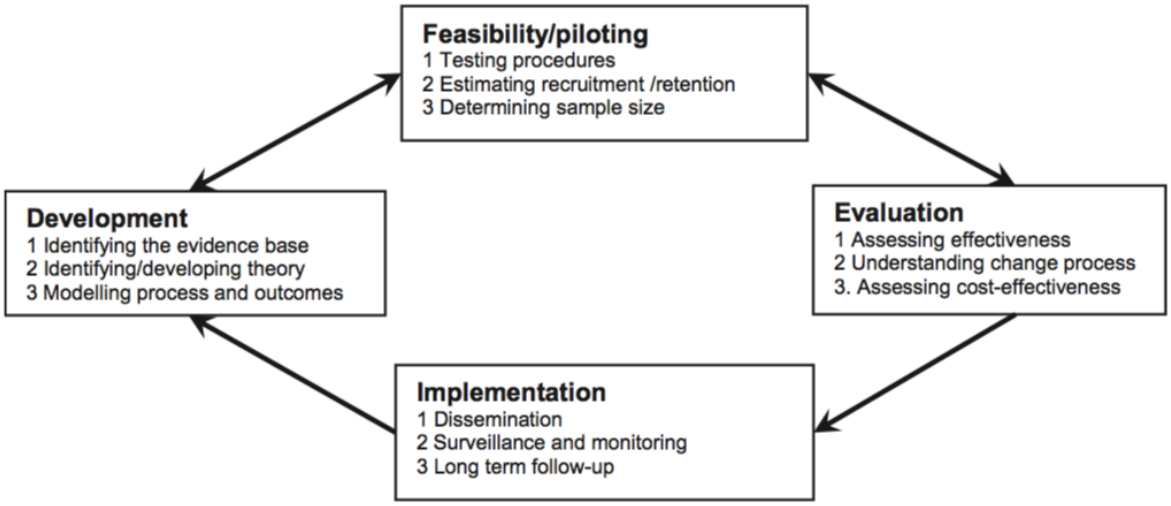


Figure 7. MRC Framework: key elements of intervention development and evaluation processes. Reprinted from "Developing and evaluating complex interventions: The new Medical Research Council guidance" by P. Craig et al., 2013, International Journal of Nursing Studies, 50(5), 589. Copyright [2012] by Elsevier Ltd. Reprinted with permission.

Nutbeam and Bauman propose a planning and evaluation cycle (Figure 8), which describes the stages in the planning, implementation and evaluation of a health promotion programme (Nutbeam & Bauman, 2014).

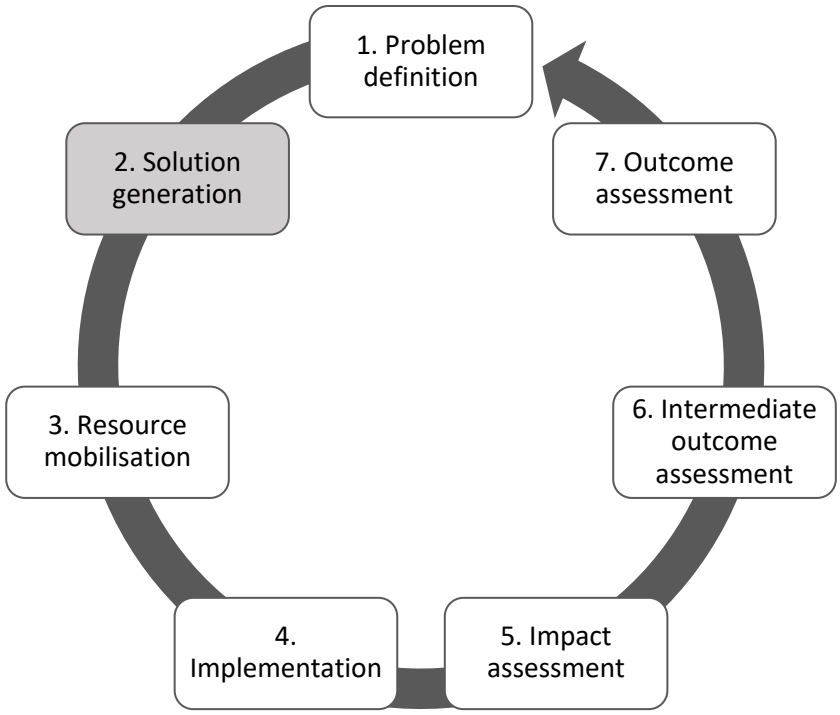


Figure 8. Nutbeam and Bauman's planning and evaluation cycle. Adapted from "Evaluation in a Nutshell" by Nutbeam & Bauman, 2014, p. 2. Copyright 2014 by McGraw-Hill Education (Australia) Pty Ltd. Permission requested.

Generating a solution is the second stage in this cycle. This stage involves identifying the process of change, the selection of effective interventions, and formative evaluation. While these elements are similar to the development phase in the MRC framework, there is a greater focus on formative evaluation in Nutbeam and Bauman's (2014) framework.

Formative evaluation (Nutbeam & Bauman, 2014) is described as the "set of evaluation steps before launch or implementation of the intervention programme. Formative evaluation includes defining the need for the programme, developing a best practice intervention using available information, consulting with the target population and bringing these stages together into a programme plan" (Nutbeam & Bauman, 2014, p. 38). Formative evaluation involves consultation with stakeholders and the target population to define and develop elements that are likely to be effective in the programme. Aspects of formative evaluation (Nutbeam & Bauman, 2014):

(i) Reviewing the problem and assessing previous efforts to address it. Appraising the impact of similar interventions by referring to literature reviews and systematic reviews in the field.

(ii) Understanding the target population using a participatory planning approach, and engaging with communities to understand barriers and facilitators. The recommended methods include focus groups and semi-structured interviews.

(iii) Formative evaluation involves pretesting or pilot testing intervention material and methods with the target audience. Various evaluation designs can be used. Pilots could assess the feasibility of the intervention, checking if it is acceptable and useful to the target population. Rigorous scientific designs like RCTs could also be used, but on a smaller scale with the aim of identifying effective intervention elements that can then be applied to a broader sample.

(iv) Formative evaluation can also be used for programme planning, using logic models and other techniques to define and describe the proposed intervention and its theoretical underpinnings.

Wight et al. (2016) reviewed existing frameworks for the development of public health interventions such as the MRC framework (Craig et al., 2013),

intervention mapping (Bartholomew, Parcel, & Kok, 1998), and a conceptual framework for planning intervention-related research (de Zoysa, Habicht, Pelto, & Martines, 1998). In a critique of existing frameworks, they commented that they tend to have a social-psychological, individual behaviour change focus, do not provide specific detail on intervention development, and require immense skills and resources. For example, a critique of the MRC framework (Craig et al., 2013) was that it focused on evaluation, and the three intervention development steps were not broken down further. Based on the strength of the existing frameworks and their own experience, the authors developed the 6SQuID (Six steps in quality intervention development) framework. The authors describe the framework as a pragmatic guide that lays out six essential steps to aid the development of public health interventions. The main steps outlined by the 6SQuID framework are:

1. Define and understand the problem and its causes
2. Clarify which causal or contextual factors are malleable and have greatest scope for change
3. Identify how to bring about change: the change mechanism
4. Identify how to deliver the change mechanism
5. Test and refine on a small scale
6. Collect sufficient evidence of effectiveness to justify rigorous evaluation/implementation

Consulting with stakeholders through all of these steps is recommended. The authors also suggest that the process need not be linear, and researchers can revisit earlier steps to refine the intervention.

2.3 Use of Intervention Development Frameworks to Design a Yoga Intervention for Older Adults

The yoga intervention developed within this PhD was based on the above mentioned frameworks. The 6SQuID framework (Wight et al., 2016) is the most recent, and incorporates many existing frameworks. It also focuses on the development stage of the intervention, and hence is the principal framework in this PhD. The MRC framework (Craig et al., 2013) and the planning and evaluation cycle

(Nutbeam & Bauman, 2014) were also included due to the emphasis on specific development aspects. For example, conducting a systematic review if none exists in the field as a part of establishing the evidence base was suggested in the MRC framework (Craig et al., 2013). The planning and evaluation cycle (Nutbeam & Bauman, 2014) was not discussed or included in the 6SQuID framework (Wight et al., 2016), and has been adopted in this PhD due to the focus and detailed description on formative evaluation. The intervention development activities undertaken based on these frameworks is presented in Table 6.

Table 6

Intervention development steps suggested by frameworks and how they were incorporated in the current project

Suggested intervention development steps	Framework	Intervention development activities for current project
Define and understand the problem	6SQuID Nutbeam and Bauman (2014)	Define physical activity. Review the benefits of physical activity and risks associated with inactivity.
Identifying the evidence base	MRC framework Nutbeam and Bauman (2014)	Conduct a systematic review and meta-analysis to assess the effectiveness of yoga in improving physical function and HRQoL measures in older adults not characterised by a specific medical condition.
Consultation with stakeholders	Nutbeam and Bauman (2014) 6SQuID	(i) Conduct focus group discussions to understand the perception of yoga in older adults and compile strategies to encourage yoga participation. (ii) Consult with yoga instructors, studio owners and researchers to get insights and feedback on strategies to adopt while working with older adults, as well as inputs on encouraging yoga participation. (iii) Procure feedback from older adults on identified intervention components.
Understand the problem and it's causes	6SQuID	Examine research studies to develop a comprehensive understanding of the causes of physical inactivity.
Clarify which causal or contextual factors are malleable and have greatest scope for change	6SQuID	Identify the barriers to physical activity that can be addressed by a yoga intervention.
Identifying theory/process of change	MRC framework Nutbeam and Bauman (2014) 6SQuID	Develop a theory of change framework to understand how the developed intervention would work.

The Tool Kit of Adaptation Approaches was also used during intervention development. The items from the typology recommended by the Pathways to Adaptation as relevant to conceptualisation and planning of the intervention were examined. While many items were more applicable while adapting interventions to suit the needs of ethnic minorities (e.g. cross-cultural training for all study personnel), items relevant to adapting a culturally unfamiliar intervention were chosen. The items have been incorporated into intervention development and are described in Table 7.

Table 7

Incorporating items from the Typology of Adaptation Approaches into intervention development

Items from the Tool Kit of Adaptation Approaches	**How the items will be incorporated into intervention development for the current PhD project**
Exploratory phase with target population	Focus groups will be conducted with older adult participants to understand their perceptions of yoga. Feedback will be procured from older adults on select intervention components.
Ethnically matched leadership within the study	Setting up of a steering group consisting of members from Scotland to provide inputs and feedback on the project.
Collaboration with ethnic specific institutions and professional organizations	Collaborating with local exercise and leisure centres.
Materials developed specifically for target population (by project investigators, expert opinion, tools); Materials created by members of the target population	Materials will be developed by the lead researcher for the target group in collaboration with them
Addresses mistrust	Materials and strategies will be developed to address apprehensions older adults may have regarding yoga
Gender taken into consideration	Gender will be considered at all stages of intervention development including ensuring male representation in focus groups and in the research team, and developing material and strategies to encourage yoga participation among the male population in Scotland.

Note. Based on Tool Kit of Adaptation Approaches (Davidson et al., 2013)

2.4 Understanding the Theoretical Underpinning of the Proposed Yoga Intervention

As discussed earlier, while the benefits of PA are established, only a small percentage of older adults adhere to the PA guidelines. Increasing PA levels can be considered a complex behaviour change, and individuals encounter several barriers with respect to PA participation (Buchan, Ollis, Thomas, & Baker, 2012). Understanding factors that influence PA participation is important, and behavioural theories have been developed so that physical activity programmes have appropriate theoretical underpinnings. These theories provide a framework to understand a complex behaviour such as physical activity and aid in identifying key factors that influence human behaviour. This section (2.4.1) briefly reviews the main behavioural theories, their main tenets and limitations. The theories presented have historically been studied in relation with physical activity, and empirically tested to understand their effectiveness in influencing physical activity behaviours (Biddle, Mutrie, & Gorely, 2015; Marcus, King, & Clark, 1997). The following theories have been reviewed:

- Theory of reasoned action
- Theory of planned behaviour
- Protection motivation theory
- Social cognitive theory
- Self-Determination Theory
- Transtheoretical Model

The section following the review of theories (section 2.4.2) contains discussions on choosing a theory for the current programme.

2.4.1 Review of behavioural theories

2.4.1.1 The theory of reasoned action and theory of planned behaviour. The theory of reasoned action (TRA) suggests that intentions influence behaviour, and are in turn linked to beliefs around the likelihood that performing a certain behaviour will produce a specific outcome (Madden, Ellen, & Ajzen, 1992). Beliefs were conceptualised as two aspects: behavioural (attitude towards performing the

behaviour) and normative (subjective norms) (Madden et al., 1992). The theory of planned behaviour (TPB) expanded on the TRA by adding a third belief that would influence intention, which is perceived behavioural control (Biddle et al., 2015). This included beliefs regarding the possession of resources and opportunities for performing a particular behaviour (Madden et al., 1992).

There is some literature to support the use of TRA and TPB within the field of PA (Buchan et al., 2012), and TPB has been found to be superior to TRA in predicting behaviour (Buchan et al., 2012). However, the two theories have some criticisms levelled against them (Biddle et al., 2015) and critics have called for the theories to be retired (Sniehotta, Presseau, & Araújo-Soares, 2014). Some criticisms of the theories are (Biddle et al., 2015):

(i) They are unidirectional and do not consider reciprocal relationships between model variables.

(ii) Models rely on beliefs and other aspects such as personality and environmental influences are not explored.

(iii) The intention to behaviour link is not explored. Hence, an individual may have the intention be physically active, but this may not translate to practice.

(iv) TRA may not predict behaviour where factors beyond 'volitional control' may be influential. TPB addresses this with the addition of perceived behavioural control. However, TPB has been criticised for inconsistency in defining and assessing perceived behavioural control. There is also a lack of evidence to support TPB using experimental methods.

2.4.1.2 Protection motivation theory. Protection motivation theory (PMT) was developed to explain the effects of fear appeals (fear arousing communication) in health behaviours (Floyd, Prentice-Dunn, & Rogers, 2000). This is based on the hypothesis that fear creating communications lead to acceptance of the recommended adaptive behaviour in an attempt to improve health outcomes (Floyd, 2000). The model consists of the threat-appraisal and coping-appraisal process. Threat appraisal involves assessing the probability and severity of the threat (Biddle et al., 2015). Coping appraisal includes response efficacy (belief that the preventative behaviour

will work) and self-efficacy (perceived confidence in actually implementing the preventative behaviour) (Floyd et al., 2000).

PMT has been tested directly within physical activity only by a few studies, and the results highlighted the role of self-efficacy rather than the aspect of health threats. Another issue with this theory as indicated by Biddle et al. (2015) is its focus on fear-based communication.

2.4.1.3 Social cognitive theory. Social cognitive theory (SCT) addresses the relationship between socio-structural determinants of health and personal determinants (Bandura, 1998). The theory proposes that behaviour is influenced by personal, behavioural and environmental factors that act bi-directionally and affect one another. The main constructs in SCT are (Young, Plotnikoff, Collins, Callister, & Morgan, 2014):
(i) Self-efficacy: This is the confidence experienced by an individual with respect to having control over their health habits.
(ii) Outcome expectations: This is the ability of individuals to think about the consequence of their actions. SCT assumes that people will pursue actions that result in positive and valued outcomes, and avoid actions they believe will bring about unfavourable outcomes.
(iii) Socio-structural factors: These are facilitators and barriers to behaviour, and could mediate the influence of self-efficacy on behaviour.

A meta-analysis identified 44 physical activity studies employing SCT and found that 31% of variance in PA was accounted for by SCT (Young et al., 2014). The review concluded that although the methodological quality was poor, SCT is a useful framework for explaining PA behaviour. While many studies have supported the use of SCT within PA, the framework has also received criticism (Beauchamp, Crawford, & Jackson, 2018).

PA research using SCT has focused mostly on the self-efficacy aspect (Beauchamp et al., 2018). Moreover, the direction of causality between goal

pursuits and self-efficacy beliefs has been highlighted as an issue. Within the theory, self-efficacy beliefs drive goal setting, which means that people usually believe they have the capability before they set goals. However, within PA, goals can also influence self-efficacy by providing structure and incentives.

The socio-structural construct in SCT is the subject of another criticism (Beauchamp et al., 2018). In order to take up a behaviour, people may have to overcome impediments which include personal, situational, social and environmental challenges. Critics however feel that these socio-structural factors may affect taking up PA in a manner that is different from that hypothesised by SCT. In SCT, socio-structural impediments are said to be mediators linking self-efficacy to goal pursuits and behaviour change. It does not fully consider the causal link between social and environmental factors and self-efficacy beliefs. The direct unmediated effects of the social environment on human behaviour are also ignored.

Another limitation of the theory is that there is evidence that self-efficacy is related to performance outcomes at a between-person level (across a group of individuals at a single time point), whereas the relationship may be negative at the within-person level (multiple time points) (Beauchamp et al., 2018). This negative relationship could result from overestimation of capability leading to complacency and consequently reduced performance. Given these issues, critics have identified a need to revisit and revise aspects of the framework (Beauchamp et al., 2018).

2.4.1.4 Self-Determination Theory. Self-Determination Theory (SDT) is a theory of motivation focusing on personality development, self-regulation, universal psychological needs (Deci & Ryan, 2008; Ryan & Deci, 2000). SDT categorises motivation as intrinsic and extrinsic motivation (Ackerman, 2018). Extrinsic motivation is influenced by external sources such as grading systems, evaluations, awards, and procuring the respect of others. Intrinsic motivation such as values, and interests come from within, and relates to the inherent satisfaction that comes from performing an activity.

The self-determination continuum begins with a state of amotivation where people act without intent or do not act at all. This is followed by four types of extrinsic motivated behaviour (Ryan & Deci, 2000). These include:
(i) External regulation: these behaviours aim to satisfy an external demand.
(ii) Introjected regulation: this is a kind of behaviour that is adopted but not accepted as one's own (Ryan & Deci, 2000). It may be carried out to avoid negative feelings or seek the approval of others (Biddle et al., 2015).
(iii) Identified regulation: this is a more autonomous form of extrinsic motivation where an outcome is regarded by the individual as valuable.
(iv) Integrated regulation: this is the most autonomous type of motivation. Here regulations have been evaluated by the individual and are "fully assimilated to the self" (Ryan & Deci, 2000, p.73). The behaviour becomes volitional due to its value in achieving one's personal goals (Biddle et al., 2015). However, it is still extrinsic as the aim is attain an outcome distinct from inherent enjoyment (Ryan & Deci, 2000).

After the types of extrinsic motivations, the SDT continuum moves towards intrinsic motivation. The continuum hence ranges from nonself-determined (amotivation) to self-determined (intrinsic motivation) (Ryan & Deci, 2000).

Another aspect of SDT is the segmenting of psychological needs into three categories (Deci & Vansteenkiste, 2004):
(i) Competence: this is the need to be effective while engaging with one's environment.
(ii) Relatedness: this refers to a universal need to feel connected to other people.
(iii) Autonomy: this is a need to act out of one's own volition in accordance with their sense of self, so that behaviour stems from choice.

Teixeira, Carraça, Markland, Silva, and Ryan (2012) conducted a systematic review to examine whether the SDT constructs predicted exercise behaviour. The review tested whether the different types of motivation were associated with involvement in exercise. Evidence of consistent support was found for a position

association between more self-determined forms of motivation and exercise. It was found that identified regulation more strongly predicted short-term exercise adoption than intrinsic motivation. Intrinsic motivation was found to be a stronger predictor of long-term exercise adherence. External regulation was found to be negatively associated, or not associated with exercise. With respect to psychological needs, competence was positively associated with exercise participation. However, social relatedness was not strongly predictive of exercise and there were mixed results for autonomy.

Limitations of SDT in physical activity mainly pertain to the methodology used by the studies. While evidence has supported the predictive value of the constructs of SDT, the methodology adopted by studies have been questioned. Most studies have used a cross-sectional approach with only few undertaking experimental research (Buchan et al., 2012). Moreover, most experimental designs have examined the use of SDT in sport and not exercise or physical activity. Hence more research with experimental designs focusing on exercise and physical activity is called for.

2.4.1.5 Transtheoretical model. The transtheoretical model (TTM) is a stage-based model which suggests that health behaviour change progresses through six stages of change: precontemplation, contemplation, preparation, action, maintenance, and termination (Prochaska & Velicer, 1997). These stages in the context of PA are described below (Biddle et al., 2015):

(i) Precontemplation: In this stage, individuals are not currently active and have no intentions of taking up PA in the near future. (I won't or I can't)

(ii) Contemplation: This is a stage where individuals are considering becoming physically active in the near future. (I might)

(iii) Preparation: Those who are participating in some PA, but not on a regular basis. These individuals are considering taking action in the immediate future. (I will)

(iv) Action: This stage consists of people who have recently become active. It is considered an unstable stage as people may relapse into inactivity. (I am)

(v) Maintenance: Here, people are active and have been so for a period of time (at least 6 months). (I have)

(vi) Termination: The termination stage does not appear in PA research (Biddle et al., 2015). It is a stage where there is no temptation to relapse and characterised by 100% self-efficacy.

The theory also identifies the process of change, which are the activities people adopt to progress through the stages (Prochaska & Velicer, 1997). Decisional balance is defined as weighing of the positive and negative aspects of effecting change (Prochaska & Velicer, 1997). Self-efficacy was discussed within the model as the confidence people possess about coping with exacting situations without relapsing to inactivity (Prochaska & Velicer, 1997).

Biddle et al. (2015) concluded that this stage-based framework may be appropriate and useful to understand behaviour change. The framework saw initial success when applied to health and PA settings (Biddle et al., 2015). A critical review of the effectiveness of PA interventions based on the TTM model concluded that these interventions are effective with respect to encouraging the adoption of PA, but the evidence did not support longer term effects on adherence to PA (Adams & White, 2003). Only one of six studies in another systematic review favoured the use of TTM compared to usual care in promoting PA (Bridle et al., 2005). Criticisms of TTM include difficulties in determining the current stage of change, as this depends on the criterions and algorithms used (Biddle et al., 2015; Hutchison, Breckon, & Johnston, 2009). Hence it was suggested that future research should focus on the distinction between stages and the possible existence of subgroups (for example, mid-precontemplaters) (Biddle et al., 2015). It has also been argued that several other factors not considered by TTM may influence PA behaviour (Hutchison et al., 2009). Moreover, studies have focussed on the stage-based aspect of the theory and facets such as processes of change, self-efficacy, and decisional balance have been neglected (Bridle et al., 2005). The processes of change in a physical activity context are understudied, and hence remain unclear (Biddle et al., 2015).

2.4.2 Choosing a theoretical model. Among the theories reviewed, SDT is one model that stands out as potentially relevant to the yoga intervention being developed in the current study. Elements identified as gaps in the logic model (Figure 6), and addressed within this PhD correspond to some of the SDT constructs. For example, creating an appealing yoga intervention would increase the inherent enjoyment of the activity (intrinsic motivation). The objective of creating a suitable intervention that the target population does not find too difficult aligns with the need for competence as described by the SDT. Adapting yoga to a different cultural context could address a need for relatedness, or connection with familiar cultural practices.

In order to choose an appropriate framework to understand the causal mechanisms underpinning the yoga intervention, the advantages and disadvantages of adopting a behaviour change theory is discussed. The relevance of behavioural theories in the current research environment is topical. A recently published paper described a debate between two researchers on whether programmes based on behavioural theory are effective in the real world (Hagger & Weed, 2019). Hagger (Hagger & Weed, 2019) argues in favour of the use of behavioural theories and emphasises their positive aspects. He suggests that the effectiveness of behavioural theories is supported by copious research evidence, and that the issue is not "effectiveness" but insufficient investment and implementation of these interventions, due to which we do not see population level long term change.

However, theories of behaviour change lack predictive or explanatory power, and there is limited evidence of their effectiveness in effecting change (Bridle et al., 2005; Hardeman et al., 2002). They often address only one or two causal factors (Wight et al., 2016), and the full range of possible influences including socio-environmental factors are neglected (Michie, Van Stralen, & West, 2011; Wight et al., 2016). They do not fully explain how the intervention elements translate to achieving intermediate and long-term outcomes.

Weed (Hagger & Weed, 2019) argued against the effectiveness of behavioural theories and a summary of his arguments are presented. He distinguishes between an intervention being efficacious (works in groups who receive it) and effective (works in cohorts who have been offered it) (Hagger & Weed, 2019). He adds that programmes based on behavioural theories claim to be effective when they are actually only efficacious. Weed also highlights that behavioural theory research is usually conducted in controlled environments. He suggested that patterns in behavioural theory interventions could merely be reflecting similar patterns in the population. For example, cross-sectional data often shows individual behavioural volatility with a proportion of the population reducing their participation in sport and a proportion increasing activity levels. Another aspect pointed out by Weed was that health outcomes are affected by health inequalities. Low employment levels, and belonging to lower socio-economic strata are associated with poorer health outcomes. These aspects are ignored by behavioural theories, which do not attempt to provide explanations or solutions to these issues.

The underlying issue as highlighted by Weed is that behavioural theories are focused on the individual rather than the population level. Citing the importance of legislation in smoking cessation, he stresses that behavioural theory played a minimal role in reduction of smoking levels. Weed thus advices a shift from individual level behavioural change intervention, to a population focus. A point of contention in Weed's argument is the stress on mandating as the only suggested method to bring about real change at a macro level. However, his criticisms of behavioural theory and suggestion to consider "social practice" to effect population level change are valid.

Programme theory examines in detail how intervention elements achieve intermediate and long-term outcomes. It was used in an earlier section (2.1) to examine underpinning evidence and identify gaps in the design and delivery of a yoga programme for older adults. It is further examined at this stage as a tool to understand how the intervention would work, and how the final outcomes would be achieved and the effects sustained. The section below provides an introduction to programme theory, highlights its importance, and briefly outlines the process.

2.4.3 Programme theory definition and importance. Funnell and Rogers describe programme theory as an "explicit theory or model of how an intervention such as a project, a programme, a strategy, an initiative, or a policy contributes to a chain of intermediate results and finally to the intended or observed outcomes" (Funnell & Rogers, 2011, p. xix). Programme theory aids in understanding how an intervention works, identifying the causal processes that occur between delivering the intervention and the outcome (Funnell & Rogers, 2011). Without programme theory, the evaluation process would resemble a black box that analyses what goes in and what comes out, but without any information on how things in between are processed. The use of programme theory also addresses some of Weed's criticisms (Hagger & Weed, 2019) of behavioural theory by identifying the cause of issues, which could go beyond behavioural aspects, and enlist different organisations and institutions to contribute towards achieving the final goals. The rationale for adopting a programme theory approach to understand the theoretical underpinnings of the yoga programme have been summarised below:

- Programme theory helps identify the mechanisms and causal processes that link the programme component to the final outcomes.
- Behavioural theories usually address only one or two causal thread, whereas a programme theory would encompass several aspects.
- The lack of predictive power is a criticism of behavioural theories. The process of developing a programme theory incorporating inputs from the target population and other stakeholders can help identify causal processes specific to the programme. Hence the programme is not force fitted to the elements of a theory, but rather has a customised theory developed through a rigorous process.
- Behavioural theories tend to focus on the individual, whereas programme theories have the capacity to incorporate a number of organisations and institutions, and their influences on the intervention and target population. This consideration of social and environmental aspects may help effect change at a population level.

It is important to acknowledge the utility of behavioural theories, and the body of research behind them. However, in the light of recent debates on the effectiveness of behavioural theory, exploring other methods to understand causal mechanisms is justified. After having reviewed several theories, and their pros and cons, it was felt that at this stage of development, it would be useful to understand all possible causal pathways. Once this broad representation of interactions between all stakeholders, activities, outputs and outcomes is developed, future iterations can choose to focus on certain aspects and integrate them within behaviour theories (this is discussed in a later section- 8.7.5).

A programme theory consists of two components (Funnell & Rogers, 2011):

(i) Theory of change. This examines the main processes or drivers through which change comes about for the intended population. These could be psychological, social, physical, or economic processes.

(ii) Theory of action. This relates to what the programme does to activate the change theory.

2.4.4 Initial theory of change model. As a preliminary exercise, an initial theory of change model was created based on the gaps and PhD activities identified in the logic model presented in Figure 6, supplemented by discussions among the lead researcher and the supervisory team. The initial theory of change model is presented as Figure 9.

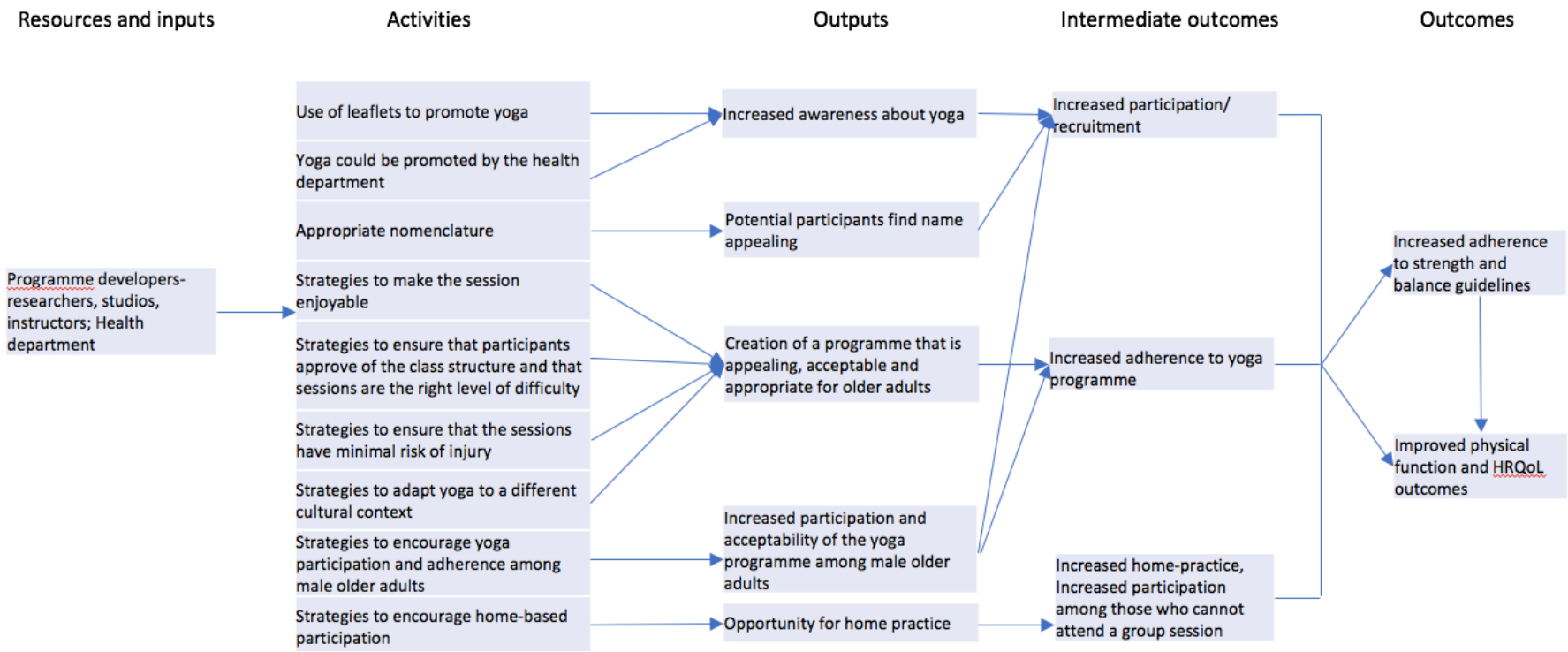


Figure 9. Initial Theory of change model

The model takes the format of a classical logic model (W.K. Kellogg Foundation, 2006). Inputs or resources include programme developers such as researchers, yoga instructors or studio owners who would be involved with increasing yoga participation among older adults. The health department was also identified as a government institution that has the potential to influence the older adult population, and encourage yoga participation. Activities such as the use of leaflets to increase yoga participation, involvement of the health department, and giving due consideration to naming the programme were identified through discussions among the research team (DS, CF,GB). Other activities (strategies to enhance the appeal of the yoga programme, ensure that the programme is not too difficult, and is safe for older adults) were derived from the gaps and corresponding activities identified in the logic model presented in Figure 6. Strategies to adapt yoga to a different cultural context, encourage participation among men and promote home-based sessions were also similarly identified. The main output is the creation of an appealing, acceptable and appropriate yoga programme. Outputs also included increasing yoga's acceptability among male groups, and creating opportunities for home practice. Leaflets were considered as a recruitment method to increase awareness about the yoga programme, and this formed the immediate output. Finding the name of the session appealing and not getting discouraged by the nomenclature is another output. These would lead to achieving the intermediate outcomes of increased recruitment and adherence to a yoga programme among older adults. The final outcomes correspond to the earlier logic model presented (Figure 6), which is the ultimate goal of increased adherence to strength and balance guidelines, and improved physical function and HRQoL.

This is a rudimentary model that has not considered previous literature on the causes of inactivity or the barriers and facilitators to yoga participation among older adults. This skeletal model provides a base structure that will be expanded using a rigorous process described by Funnell and Rogers (2011) to produce a theory of change model for the final yoga programme.

2.5 Theory of Change Framework for the Final Yoga Programme- Methodology

Funnell and Rogers (2011) describe three approaches to developing a programme theory.

(i) Articulating stakeholder's mental models. This is an approach that involves working with stakeholders to understand their ideas and beliefs on how the programme is going to achieve its goals, and what success would look like.

(ii) Deductive development. This involves referring to documentation about problems the programme is addressing including its causes and consequences. Wider literature about the programme such as guidelines and previous evaluations, and inputs from experts could also feed into development. Deductive approaches include logical analysis (tracing relationships between the causes of the problem and programme components). They are said to be useful for identifying the "espoused theory" (the stated position about how the programme ought to work).

(iii) Inductive approach. Inductive approaches involve observing how the programme works in practice and deriving the programme theory after implementation. Programme theory is derived based on participant observation and interviews with stakeholders.

The deductive approach will be used to derive the programme theory for this project. This will involve (i) Examining the problem of inactivity and its causes in detail, referring to published literature. (ii) Utilising inputs from yoga teachers and the target population to inform the programme theory. (iii) Using logical analysis to derive the mechanisms underlying the programme.

Three features of a theory of change were presented by Funnell and Rogers (2011), and these will be used to develop a programme theory for the current project:

(i) Situation analysis. A situation analysis involves identifying the problem being investigated including its features, causes and consequences (Funnell & Rogers, 2011). The main problem addressed in this project is physical inactivity in older adults, especially focussing on the strength and balance recommendations. The

problem and its consequences have been discussed in detail (sections 1.6, 1.8, 1.9, 1.10, 1.11, 1.17). An in-depth exploration of the causes of inactivity will be undertaken as a part of this analysis.

(ii) Focus and scoping. The situation analysis would produce an index of factors affecting physical inactivity. From this, factors specifically addressed by the developed yoga programme will be identified. A Fishbone diagram will be developed which would encompass all the factors associated with inactivity categorised as i) addressed by the programme or ii) out of scope.

(iii) Outcome chain. An outcome chain would be developed linking activities to outputs, intermediate and final outcomes. Here, the data from literature, inputs from the target population and other stakeholders will be assimilated. The final outcomes in the outcome chain will reflect the main goals of the programme.

Through the process mentioned above, a theory of change for the final yoga programme will be developed.

2.6 Objectivity and Trustworthiness of Data in this PhD Thesis

The following measures were taken to ensure objectivity and trustworthiness of data collected and analysed in this PhD:

(i) Systematic review: The systematic review will be conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009), and the protocol will be registered in advance on PROSPERO.

(ii) Qualitative studies: The COREQ (COnsolidated criteria for REporting Qualitative research) check list (Tong, Sainsbury, & Craig, 2007) will be adhered to while reporting on the qualitative studies. Reporting of participant quotations to illustrate themes has been suggested in the COREQ checklist and this will aid unbiased reporting.

(iii) Supervision and steering group: Although the lead researcher (DS) is a yoga teacher, the supervisory team and steering group consisting of diverse members including physical activity experts and a Surgeon at the Royal Infirmary Edinburgh

provided objective advice that helped minimise bias throughout the course of the PhD.

2.7 PhD Stages and Activities

Research gaps and activities were identified using a literature review, intervention development frameworks, and the Tool Kit of Adaptation Approaches and presented as a logic model. Based on this, the stages of the PhD and activities to be undertaken at each stage are outlined:

(1) Define and understand the problem: The definition of PA and a review of its benefits as well as the risks associated with inactivity have been described in Chapter 1. Physical inactivity in older adults, and yoga as a proposed solution have also been discussed (sections 1.6, 1.8, 1.9, 1.10, 1.11, 1.14, 1.17).

(2) Identifying the evidence base: A systematic review and meta-analysis to assess the effectiveness of yoga in improving physical function and HRQoL outcomes in older adults not characterised by a specific medical condition (Study 1 of PhD project, Chapter 3).

(3) Consultation with stakeholders: (i) Focus group discussions to understand the perception of yoga in older adults, and compilation of strategies to encourage yoga participation (Study 2 of PhD project, Chapter 4). (ii) A knowledge exchange (KE) event to share research evidence with yoga instructors, studio owners and yoga researchers, and procure feedback and insights from them (KE event, Chapter 4). (iii) A study to evaluate intervention components identified in Chapter 4 and obtain further insights from the target group to refine the intervention (Study 3 of PhD project, Chapter 5).

(4) Understand the problem and its causes; Clarify which causal or contextual factors are malleable and have greatest scope for change; Identify theory/process of change: Compile the final yoga programme based on Studies 1, 2 and 3 (Study 4 of PhD project, Chapter 6). An analysis to understand the barriers to PA, and to identify how the yoga programme components can address these barriers forms a part of Study 4 (Chapter 7). A theory of change framework developed to understand how the final yoga programme would work to achieve ultimate outcomes (Study 4 of PhD project, Chapter 7). The stages of the PhD are summarised in Figure 10.

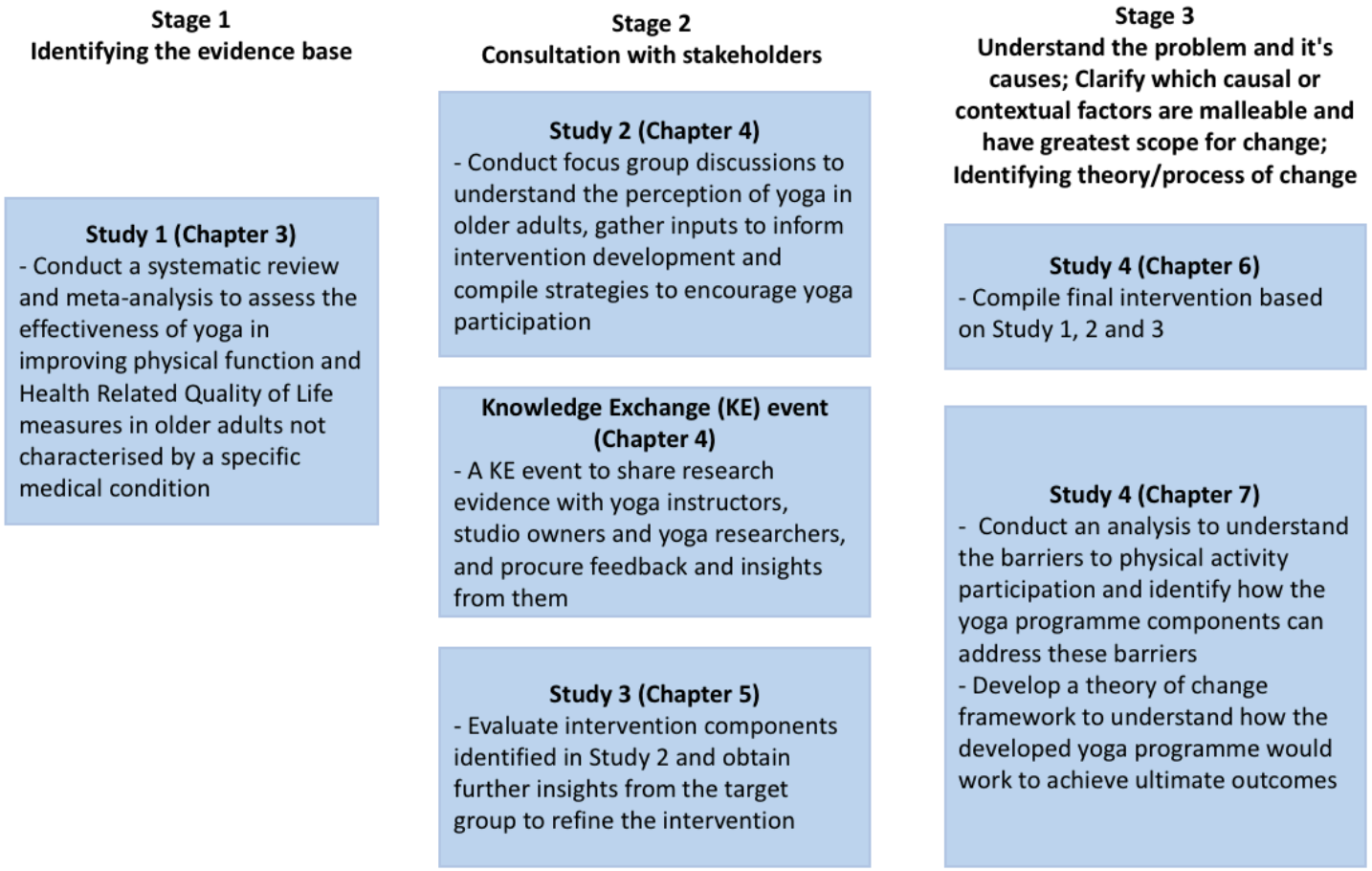


Figure 10. Stages, studies and chapters of this PhD

Chapter 3. Systematic Review of the Effects of Yoga on Older Adults

This PhD project aims to develop a yoga programme that would improve physical function and HRQoL in older adults, and Study 1 of the PhD is a systematic review to assess if yoga improves these outcomes for this population.

3.1 Published manuscript

The systematic review was published on 5th April 2019 in the International Journal of Behavioral Nutrition and Physical Activity.

Title: The effects of yoga compared to active and inactive controls on physical function and health related quality of life in older adults- Systematic review and meta-analysis of randomised controlled trials
Authors: Divya Sivaramakrishnan, Dr. Claire Fitzsimons, Dr. Paul Kelly, Kim Ludwig, Prof. Nanette Mutrie, Dr. David H Saunders, Dr. Graham Baker

The final author manuscript is presented in this section. The paper has been included as a supplementary file (Appendix 2)

3.2 Background

The World Health Organization's physical activity (PA) recommendations for older adults (aged 65 years and over) include aerobic, muscle strengthening and balance components (World Health Organization, 2011a). Physical activity levels worldwide decrease with age (Hallal et al., 2012), and the percentage of older adults meeting these recommendations remains low. The United Kingdom (UK) PA guidelines for this age group include the accumulation of at least 150 minutes of moderate intensity activity or 75 minutes of vigorous activity per week (MVPA guidelines), as well as activities to improve muscle strength, and balance and coordination on at least two days a week (Department of Health, 2011). Thirty-one percent of adults aged 65-74 years and 54% of adults aged 75+ years in England (2015-2016) (National statistics, 2017), and 53% of men and 66% of women aged 65 years and over in Scotland (2012-2014) (Strain, Fitzsimons, Foster, et al., 2016), did

not meet the MVPA guidelines. The balance guidelines were met by 19% of older men and 12% of older women in Scotland (Strain, Fitzsimons, Kelly, et al., 2016); and only 14% of men and 12% of women in the 65-74 age-group, and nine percent of men and four percent of women over 75 years met the muscle strength guidelines (Strain, Fitzsimons, Kelly, et al., 2016). Accordingly, the World Health Organization identifies older adults as a strategic priority area for the promotion of physical activity (Regional Committee for Europe 65th Session, 2015).

Yoga is an ancient practice and a way of life that originated in India, and includes the practice of postures, regulated breathing and meditation (Saraswati, 2008). It is a mode of activity found to have multiple benefits for older adults (Patel et al., 2012; Wang et al., 2014; Youkhana et al., 2016). Previous systematic reviews have provided evidence on the beneficial effects of yoga in older adults in terms of promoting cardiovascular health (Barrows & Fleury, 2015), balance and mobility (Youkhana et al., 2016), depression and quality of sleep (Wang et al., 2014). A recent systematic review and meta-analysis by Tulloch et al. (Tulloch et al., 2018) found that yoga had a medium effect on health related quality of life (HRQoL), and a small effect on mental wellbeing in people aged 60+ years. In this review, HRQoL was measured by physical component summary scales, and mental wellbeing was assessed by mental component summary scales from questionnaires like SF-36 and WHOQOL. However, HRQoL has been described as a concept encompassing several aspects of overall quality of life that can be clearly shown to affect health (Centers for Disease Control and Prevention, 2016), including anxiety, stress, depression, vitality, social health and sleep (Rejeski & Mihalko, 2001), which were not assessed in the review.

Physical function is another relevant outcome for the older adult population and includes aspects such as cardio-respiratory fitness, muscular strength, flexibility and balance (Halter & Reuben, 2000; Kaminsky, 2010). Benefits of performing muscle strength activities in older adults include the offsetting of age-related muscle loss (sarcopenia), enhanced functional performance, improved bone mineral density (BMD), and prevention of falls (Kelley et al., 2001; Lang et al., 2010). Whilst yoga

has been specifically recommended as a muscle strengthening activity as part of several national PA guidelines including the UK and US (Department of Health, 2016; United States Department of Health and Human Services, 2008), there have been no previous attempts to synthesise the evidence base to support this recommendation for the older adult population. Patel et al. (Patel et al., 2012) studied the effects of yoga on some physical function and HRQoL outcomes in older adults from randomised controlled trials (RCT) published between 1950 and 2010. Results of the meta-analysis showed that yoga may be significantly better than controls in improving self-rated health status and aerobic fitness, but no significant differences were found for depression. However, the narrative and quantitative analysis in the Patel et al. review (Patel et al., 2012) combined data in which yoga was compared with active (example: walking, Tai chi, stretching exercises) and inactive controls (example: usual care, socialisation, education group), making it difficult to draw conclusions on whether any true effects (statistically significant) of yoga compared to other exercise programmes exist, and the strength (magnitude) of these effects.

Tulloch et al. (Tulloch et al., 2018) and Patel et al. (Patel et al., 2012) included studies involving older participants with clinical conditions. Other systematic reviews have focused on yoga in specific clinical groups such as cancer (Buffart et al., 2012), Type 2 Diabetes (Aljasir, Bryson, & Al-shehri, 2010; Innes & Vincent, 2007) and rheumatic diseases (Cramer, Lauche, Langhorst, & Dobos, 2013b), and found some evidence that yoga has beneficial effects on physiological, physical function and psychosocial outcomes in these populations. Results from studies which only recruited participants with specific diseases or conditions cannot be generalised to all older adults. The yoga interventions used in studies involving clinical populations may have been specially developed to address particular symptoms (example: dyspnea related distress in older adults with chronic obstructive pulmonary disease (Donesky-Cuenco, Nguyen, Paul, & Carrieri-Kohlman, 2009)). It is also difficult to disentangle the effects of yoga when data from heterogeneous groups with different clinical conditions are merged in a review.

Therefore, the present systematic review aims to address limitations in previous reviews and expand on existing evidence in three ways: i) including a comprehensive list of physical function and HRQoL outcome measures; ii) comparing yoga against distinct active and inactive controls so that the relative benefits of yoga can be assessed; and iii) reviewing the effectiveness of yoga in studies where older adult participants were not recruited on the basis of a specific disease or condition. The objective of this review was to assess the effectiveness of yoga compared to active and inactive controls on physical function and HRQoL in older adults not characterised by a specific clinical condition, based on randomised/cluster randomised controlled trials.

3.3 Methods

The review was conducted in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009), and recommendations of the Cochrane collaboration (Higgins, Green, Cochrane, Higgins, & Wiley, 2008). The protocol was developed in advance of the study and registered on PROSPERO (Registration number: CRD42016038052).

3.3.1 Search and selection criteria. The inclusion and exclusion criteria for studies were as follows: (i) Participants: older adults defined as mean age 60 years and above, not recruited on the basis of a specific disease or condition were included; (ii) Intervention and comparison: studies comparing yoga interventions with active and inactive controls were included. Studies in which yoga was specified as a control condition or where yoga was combined with other practices or exercise forms were excluded; (iii) Outcomes: only studies reporting physical function and/or HRQoL outcomes were included; (iv) Study type: studies with a randomised (including cluster randomised) controlled study design published in English were included.

A mean age of 60 years and above was a criterion for inclusion. The retirement age in countries like India and China is 60 years (Trading Economics; Trading Economics), and the United Nations defines older persons as those aged 60 years or over (United Nations, 2015). To accommodate these definitions of old age,

the age criterion for inclusion in this review was set as a mean of 60+ years. Another criterion was the inclusion of participants who were not recruited based on a disease or condition, and this meant excluding studies in which participants were recruited specifically if they had a particular disease or clinical condition. However, studies with frail, inactive older adults, and those with poor balance were included in the review.

Studies with yoga as a control group were excluded from the review (n = 6) (Blumenthal et al., 1989; Blumenthal et al., 1991; Bowman et al., 1997; Emery & Blumenthal, 1990; Madden, Blumenthal, Allen, & Emery, 1989; Stachenfeld et al., 1998). In these studies, the yoga group was used to control for aspects such as social stimulation and attention from trainers, without producing an aerobic response. The reporting for the controls was not rigorous, and the yoga programmes were not described in detail. Some studies dated back to 1989, making it difficult to procure the necessary data for them.

3.3.2 Search and screening. Database searches were conducted in September 2017. The following databases were searched (from inception till September 2017): Medline, PsycInfo, CINAHL Plus, Scopus, Web of Science, Cochrane Library, Embase, SPORTDiscus, AMED, ProQuest Dissertations & Theses Global. The search was conducted using key words related to "yoga" and "older adults". A detailed list of the search terms used is presented in the supplementary section (Appendix 3). The outcome and study type criteria were applied at the screening stage. The reference lists of included studies were also checked for additional relevant studies (Horsley, Dingwall, Tetzlaff, & Sampson, 2009).

Screening was carried out in three stages using reference management software (EndNote X7.2.1). First, a preliminary title and abstract screening was performed by one researcher (DiS) where duplicates and obviously irrelevant studies were removed. Five percent of the search results were cross-checked by another researcher (KL). Second, titles and abstracts of all studies were screened by two

researchers (DiS, KL) with studies categorized as “Yes” (satisfied eligibility criteria), “No” (did not satisfy eligibility criteria) and “Maybe” (uncertain, and need further scrutiny). Finally, full texts of studies in the “Yes” and “Maybe” categories were screened in further detail by two researchers (DiS, KL). Disagreements were resolved by a third researcher (CF or GB).

3.3.3 Data extraction. A custom data extraction form for descriptive characteristics (Appendix 4) was developed and piloted by three researchers (DiS, GB, CF). Descriptive data were extracted for all included studies by one researcher (DiS), and 33% of these were cross-checked by another researcher (GB or KL). Outcome data were extracted by one researcher (DiS), and 100% cross-checked by another researcher (KL). Discrepancies were resolved through discussions among the researchers (DiS, KL). Authors of studies for which outcome data were not available were contacted and requested to provide the data, and were asked for clarifications if required. One study only reported median, minimum and maximum values for outcome variables (Vogler, O'Hara, Gregg, & Burnell, 2011). Means and standard deviation were imputed from these data (Hozo, Djulbegovic, & Hozo, 2005; Walter & Yao, 2007; Weir et al., 2018), and the study was included in the meta-analysis.

3.3.4 Quality assessment. Risk of bias was assessed independently by two researchers (DiS, KL) using the Cochrane risk of bias tool (Higgins & Altman, 2008). The following domains were assessed for physical function and HRQoL outcomes separately: selection bias (random sequence generation, allocation concealment), detection bias (blinding of outcome assessment), attrition bias (incomplete outcome data), reporting bias (selective reporting), and other bias (sample selection bias (Henderson & Page, 2007; Kate Ann, 2005; Krishna, Maithreyi, & Surapaneni, 2010; Pannucci & Wilkins, 2010), contamination bias (Kate Ann, 2005; Krishna et al., 2010), compliance bias (Krishna et al., 2010) and response bias (Furnham, 1986)). Performance bias (blinding of participants and personnel) was not assessed as it is impossible to blind participants and personnel in a yoga intervention study. Under each domain, studies were classified as low, high or

unclear risk of bias. Discrepancies were resolved through discussion between the two researchers.

3.3.5 Analysis. For the physical function and HRQoL variables, separate analyses comparing yoga with active and inactive groups were conducted. Other sub-group analyses such as types of yoga and gender were not explored. Though different yoga types have been used in the included studies, there is similarity between types in terms of the structure and postures followed and hence, it was not considered appropriate to compare them. Further, the requisite outcome data were not readily available by gender for a majority of studies.

3.3.5.1 Vote-counting. As a preliminary analysis, a 'vote counting' approach was adopted (Bushman & Wang, 2009), where three categories were created for each outcome: statistically significant (as reported by authors) positive effects favouring the yoga group, statistically significant negative effects (i.e., favouring the control group), and no significant difference between groups. For every outcome, effects of yoga was based on the category with the highest number of vote counts. For example, for strength, if the majority of studies found significant positive results favouring yoga, then yoga was considered to have a positive effect (Bushman & Wang, 2009). Vote-counting has been critiqued as crude and flawed as it does not give due weight to sample size and effect size (ES). However, when used in conjunction with a meta-analysis, the method can provide a comprehensive understanding of the studies and outcomes included, and the effects of the intervention (Bushman & Wang, 2009). The vote-counting approach helped create a catalogue of all results from every study included in the systematic review, providing a foundational structure based on which the data for the meta-analysis were generated. The vote counting analysis included all outcomes assessed by more than one study, and the included outcomes are presented in Table 8.

Table 8
List of outcomes included and not included in vote-counting and meta-analysis

Analysis	Active/inactive control group	Physical functioning outcomes	HRQoL outcomes
Vote counting analysis	Yoga vs inactive controls	Body composition measures (body mass index (BMI), body weight, body fat percentage, waist circumference), cardio-respiratory fitness, strength (lower and upper limb strength, hand grip strength), flexibility (lower and upper body flexibility, range of motion (ROM)), mobility, walking speed, balance, fall frequency	Anxiety, depression, perceived physical health, perceived mental health, general health and wellbeing (subscale from SF-12 and SF-36), vitality, quality of life, social health, sleep quality, stress, fear of falls, balance confidence
	Yoga vs active controls	Strength (lower and upper limb strength), flexibility (lower and upper body flexibility), mobility, walking speed, balance, fall frequency	Anxiety, depression, perceived physical health, perceived mental health, vitality, stress
Meta-analysis	Yoga vs inactive controls	Body composition (BMI, body weight and body fat percentage), balance, lower body flexibility, upper body flexibility, walking speed, lower limb strength	Depression, fear of falls, perceived mental health, perceived physical health, sleep quality, social health, vitality
	Yoga vs active controls	Balance, lower body flexibility, lower limb strength, mobility, walking speed	Anxiety, depression, perceived mental health
Not included in vote-counting or meta-analysis (measured by just one study)	Yoga vs inactive controls		Anger (Bonura & Tenenbaum, 2014), self-control (Bonura & Tenenbaum, 2014), fatigue (Oken et al., 2006), motivational factors to exercise (Bethany, 2005), pain (Saravanakumar, Higgins, Van Der Riet, Marquez, & Sibbritt, 2014), mood (Oken et al., 2006), hope (Wang, 2010), medication usage (Haber, 1988), capacity for self-care (Haber, 1988), self-efficacy (general, and for chronic disease) (Bonura & Tenenbaum, 2014)
	Yoga vs active controls	Cardio-respiratory fitness (Noradechanunt, Worsley, & Groeller, 2017)	Anger (Bonura & Tenenbaum, 2014), self-control (Bonura & Tenenbaum, 2014), fatigue (Oken et al., 2006), motivational factors to exercise (Bethany, 2005), pain (44), mood (Oken et al., 2006) , social health (Oken et al., 2006) , general health and well-being (Oken et al., 2006) , quality of life (Saravanakumar et al., 2014), balance confidence (Morris, 2008), fear of falls (Morris, 2008), self-efficacy (general, and for chronic disease) (Bonura & Tenenbaum, 2014)

3.3.5.2 Meta-analysis. For outcomes where quantitative data from three or more studies were available, a meta-analysis was conducted using the Comprehensive Meta-Analysis Version 3, Professional software. The outcomes included in the meta-analysis are presented in Table 8. Some studies used more than one test or instrument to measure an outcome. Since only one of these could be included in the meta-analysis, the test most commonly reported by the included studies was chosen. For balance, only functional assessments (Mancini & Horak, 2010) such as one leg stand test, Berg balance scale, standing balance tests from the Short Physical Performance Battery, and Performance Oriented Mobility Assessment (POMA) were included in the meta-analysis. Objective measures like static and dynamic posturography (Mancini & Horak, 2010) were not included due to the lack of a composite index and difficulties in interpreting the data. A random effects model was used as it better models data from heterogeneous populations (Deeks, Higgins, & Altman, 2008). Data at pre-intervention and immediately following the intervention were analysed, and effect sizes were calculated based on change (post minus pre) scores. Since various different instruments and units were used by studies to measure outcomes, calculation of mean differences was not possible, and standardized mean differences (SMD) were computed instead (Deeks et al., 2008). Hedges' g statistic was used to compute effect sizes, and Forest plots were created with 95% confidence intervals (CI). Effect sizes were categorised as small (0.2 to 0.5), moderate (0.5 to 0.8) and large (> 0.8) using Cohen's categories (Cohen, 1988). Statistical heterogeneity between studies was assessed using the I^2 statistic. Heterogeneity was categorised as low (I^2 = 0% to 40%), moderate (I^2 = 30% to 60%), substantial (I^2 = 50% to 90%) and considerable (I^2 =75% to 100%) (Deeks et al., 2008).

One study had two yoga intervention groups and one control group (Chen et al., 2008). Both yoga groups were included in the meta-analysis, each one compared with half the number of participants in the control group (Higgins, Deeks, & Altman, 2008). Four studies (Bethany, 2005; Krishnamurthy & Telles, 2007b; Manjunath & Telles, 2005; Ni, Mooney, Richards, et al., 2014) had one yoga intervention group and two control groups. In these cases the result was included twice in the meta-

analysis with half the number of participants for the yoga group each time (Higgins, Deeks, et al., 2008). Following this, two sensitivity analyses were also conducted: (i) comparing the full yoga intervention arm and the first control group, and (ii) comparing the full yoga intervention arm and the second control group. Five included studies (Chen et al., 2009; Chen et al., 2008; Chen, Chen, et al., 2010; Chen, Fan, et al., 2010; Manjunath & Telles, 2005) used cluster randomisation, and an iteration of the meta-analysis was run after adjusting the number of participants in the studies to account for this (adjusted sample size = original sample size /design effect, where design effect = 1+ (Average cluster size - 1)*Intracluster Correlation Coefficient; calculations presented in Appendix 5) (Higgins, Deeks, et al., 2008). Four studies (Chen et al., 2009; Chen et al., 2008; Chen, Chen, et al., 2010; Chen, Fan, et al., 2010) had the requisite data for cluster randomisation adjustment, and one study (Manjunath & Telles, 2005) was removed from this analysis due to lack of data. There were insufficient studies (less than 10) in the meta-analyses to test for publication bias using funnel plots (Sterne, Egger, & Moher, 2008).

3.4 Results

7996 records were identified through the data searches, and after the three stages of screening, 27 records from 22 RCTs (Figure 11) were included in the systematic review. Seventeen RCTs with 967 participants assessed physical function, and 20 RCTs with 1567 participants assessed HRQoL.

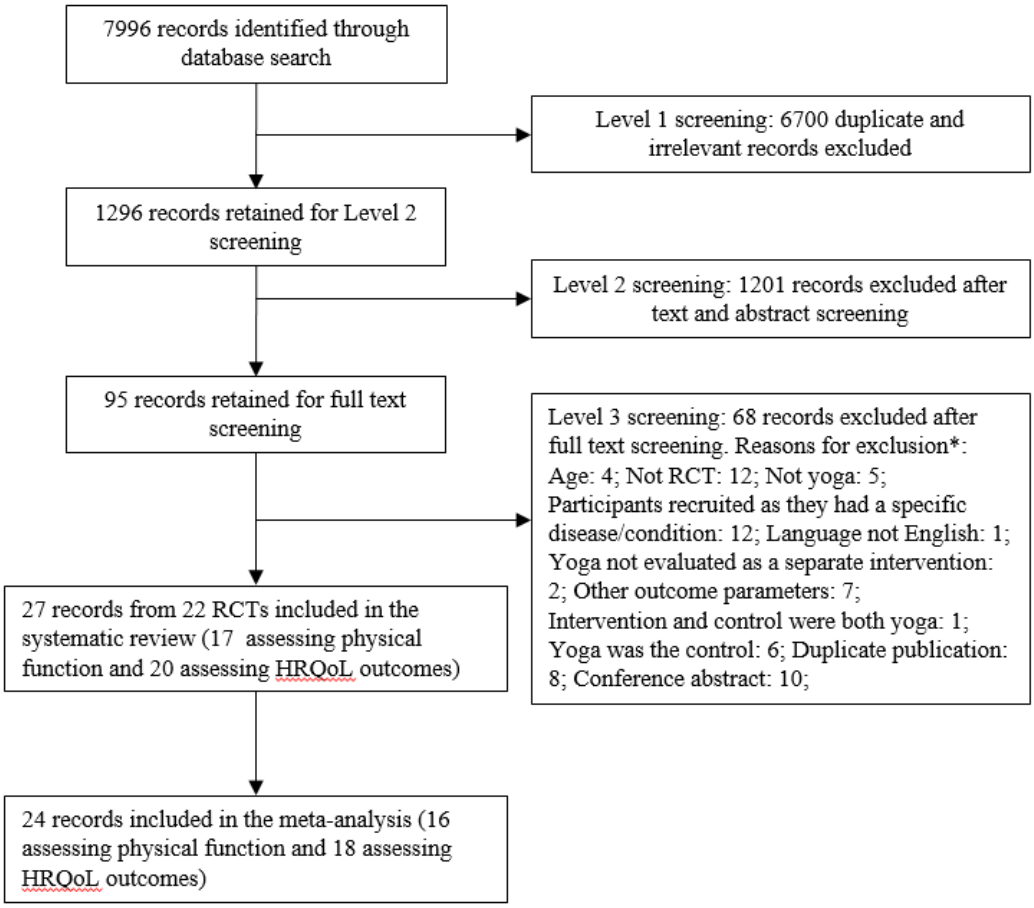


Figure 11. Flow of studies through the review. Studies could have been excluded for more than one reason

3.4.1 Study and participant characteristics. Study and participant characteristics are presented in Table 9. Ten studies were from the USA (Bethany, 2005; Bonura & Tenenbaum, 2014; Gothe, 2013; Haber, 1983, 1988; Leininger, 2006; Morris, 2008; Ni, Mooney, Richards, et al., 2014; Oken et al., 2006; Wang, 2010), four from Australia (Noradechanunt et al., 2017; Saravanakumar et al., 2014; Tiedemann, O'Rourke, Sesto, & Sherrington, 2013; Vogler et al., 2011), two from Taiwan (Chen et al., 2008; Chen, Fan, et al., 2010), two from India (Hariprasad, Sivakumar, et al., 2013; Manjunath & Telles, 2005), and one each from Brazil (Bezerra et al., 2014), Iran (Nick, Petramfar, Ghodsbin, Keshavarzi, & Jahanbin, 2016), UK (Tew et al., 2017) and Portugal (Marques et al., 2017). The number of participants in studies ranged from 18 to 410, and the mean size was 77 ± 84.

The mean age of participants in the studies ranged from 61.0 years to 83.8 years. In 15 studies, more than 70% of the participants were female. The attendance rates for class-based yoga sessions ranged from 67% to 100%, and for active controls it was 62% to 91%. Four studies reported adverse events in the yoga group (groin muscle strain (Oken et al., 2006), fall during yoga session (Saravanakumar et al., 2014), and musculoskeletal pain (Tew et al., 2017; Tiedemann et al., 2013)). Four studies reported that there were no adverse events during the course of the yoga intervention (Chen et al., 2008; Chen, Fan, et al., 2010; Gothe, 2013; Leininger, 2006).

Table 9

Participant, intervention and study characteristics

Study Country	**Participants (number, mean age (SD))**	**Intervention group (type, frequency, session duration, length of intervention**	**Control group(s)**	**Outcome measures**
Bezerra et al. (2014) Brazil	N = 36 Mean age (SD): yoga group = 63.1 (13.3); control group = 61.0 (6.9) years.	Yoga, 3 times a week, 65 minutes per session 12 weeks	1. IC: Control group	Physical function: Body weight
Bonura and Tenenbaum (2014) USA	N = 98 Mean age (SD): 77.04 (7.28) years	Chair yoga, 1 session a week, 45 minutes per session , 24 weeks	1. AC: Chair exercise 2. IC: Wait-list control	HRQoL: Anger, anxiety, depression, well-being, general self-efficacy, self-efficacy for daily living, self-control
Bethany (2005) USA	N = 42 Mean age (SD) = 83.14 (4.84) years	Chair yoga, 3 times a week, 30 minutes per session, 6 weeks	1. AC: Chair aerobics 2. AC: Walking programme 3. IC: Game playing	HRQoL: Stress frequency, stress severity, state anxiety, depression, motivational factors to exercise

Chen et al. (2008) Taiwan	N = 176 Mean age (SD): Complete Silver Yoga = 65.81 (4.34); Shortened Silver Yoga = 68.08 (6.32); control group = 72.42 (6.04) years	1. Complete Silver Yoga with meditation, 3 times a week, 70 minutes per session 24 weeks 2. Shortened Silver Yoga, 3 times a week, 55 minutes per session 24 weeks	1. IC: Wait-list control	Physical function: Bodyweight, BMI, body fat percentage, lower body flexibility, upper limb strength, lower limb strength, balance, walking speed, range of motion: flexion and abduction of shoulder and hip joints on both sides
Chen et al. (2009) Taiwan	N = 128 Mean age (SD): 69.20 (6.23) years	Silver Yoga, 3 times a week, 70 minutes per session, 24 weeks	1. IC: Wait-list control	HRQoL: Sleep quality, depression, perceived mental and physical health
Chen, Chen, et al. (2010) (Figures: Chen (2010)1) Taiwan	N = 55 Mean age (SD): 75.40 (6.70) years	Silver Yoga, 3 times a week, 70 minutes per session, 24 weeks	1. IC: Wait-list control	HRQoL: Sleep quality, depression, perceived mental and physical health
Chen, Fan, et al. (2010) (Figures: Chen (2010)2) Taiwan	N = 55 Mean age (SD): 75.40 (6.70) years	Silver Yoga, 3 times a week, 70 minutes per session, 24 weeks	1. IC: Wait-list control	Physical function: Body weight, BMI, body fat percentage, cardiopulmonary fitness, upper body flexibility, lower body flexibility and range of motion: flexion and abduction of shoulder and hip joints on both sides, upper limb and lower limb muscle strength, balance, and walking speed
Gothe and McAuley (2016) USA	N = 108 Mean age (SD): yoga group = 62.1 (5.82), control group = 62.0 (5.39) years	Hatha yoga, 3 times a week, 60 minutes per session, 8 weeks	1. AC: Stretching–strengthening control group	Physical function: Mobility, upper and lower limb strength, upper and lower body flexibility, balance, walking speed
Gothe (2013) USA	N = 108 Mean age (SD): yoga group= 62.1 (5.82), control group = 62.0 (5.39) years	Hatha yoga, 3 times a week, 75 minutes per session, 8 weeks	1. AC: Stretching–strengthening control group	HRQoL: Stress, anxiety

Haber (1983) USA	Centre1 N: 51 Mean age: 69 years Centre 2 N: 35 Mean age: 70 years	The Easy Does it Yoga Programme for Older People 1 session a week, Daily home practice encouraged, 10 weeks	1. IC: Control group (film series or art class)	HRQoL: Self assessed health status, psychological wellbeing
Haber (1988) USA	N = 410 Mean age: 75 years	The Easy Does it Yoga Programme for Older People, 3 times a week, 60 minutes per session, 10 weeks	1. IC: Control group	HRQoL: Self-care, sociability, medication usage
Hariprasad, Sivakumar, et al. (2013) India	N = 87 Mean age (SD): yoga group = 75.74 (6.46), control group = 74.78 (7.35) years	Yoga, daily supervised sessions for 1 month. 1 session per week in the 2nd and 3rd month. Daily home practice following this, 60 minutes per session, 24 weeks	1. IC: Wait-list control	HRQoL: Perceived physical and mental health, sleep
Krishnamurthy and Telles (2007a) (Figures: Krishnamurthy (2007)) India	N = 50 Mean age (SD): yoga group= 70.1 (8.3), ayurveda= 72.1 (9.0), wait-list= 72.3 (7.4) years	Yoga, 6 times a week, 60 minutes per session, 24 weeks	1. IC: Ayurveda group (herbal preparation) 2. IC: Wait-list control	Physical function: Balance, mobility
Krishnamurthy and Telles (2007b) (Figures: Krishnamurthy (2007)2) India	N = 50 Mean age (SD): yoga group= 70.1 (8.3), ayurveda= 72.1 (9.0), wait-list= 72.3 (7.4) years	Yoga, 6 times a week, 60 minutes per session, 24 weeks	1. IC: Ayurveda group (herbal preparation) 2. IC: Wait-list control	HRQoL: Depression
Leininger (2006) USA	N = 82 Mean age (SD): yoga group= 69.6 (6.7), education group= 68.2 (5.4) years	Hatha yoga, 2 supervised sessions a week. Home exercises recommended at least three times a week, 60 minutes per session , 10 weeks	1. IC: Education control group (on topics of osteoporosis and fitness)	Physical function: Balance, strength, HRQol: Balance confidence, vitality

Manjunath and Telles (2005) India	N = 50 Mean age (SD): yoga group = 70.1 (8.3), ayurveda = 72.1 (9.0), wait-list = 72.3 (7.4) years	Yoga training, 6 times a week, 60 minutes per session, 24 weeks	1. IC: Ayurveda (herbal preparation) 2. IC: Wait-list control	HRQoL: Sleep quality
Marques et al. (2017) Portugal	N = 25 Mean age (SD): 83.16 (7.4) years	Chair based yoga, 2 to 3 times a week 50 minutes per session, 28 weeks	1. IC: Control group given education booklet	Physical function: Cardio-respiratory fitness, mobility, upper body flexibility HRQoL: Stress, perceived mental health
Morris (2008) USA	N = 18 Mean age (SD): 76.06 (6.35) years	Hatha yoga, 2 times a week, 60 minutes per session, 8 weeks	1. AC: Balance training exercise 2. IC: Fall risk awareness	Physical function: Balance, fall frequency HRQoL: Fear of falls, balance confidence
Ni, Mooney, Richards, et al. (2014) USA	N = 39 Mean age (SD): 74.15 (6.99) years	Balance yoga programme, 2 times a week, 60 minutes per session, 12 weeks	1. AC: Tai Chi 2. AC: Standard balance programme	Physical function: Mobility, balance, walking speed
Nick et al. (2016) Iran	N = 39 Mean age (SD): yoga group = 68 (4.87), control group = 68.79 (4.81) years	Hatha yoga, 2 times per week, 60 minutes per session, 8 weeks	1. IC: Control group	Physical function: Balance HRQoL: Fear of falls
Noradechanunt et al. (2017) Australia	N =33 Mean age (SD): 67.7 (6.7) years	Thai Yoga, 2 supervised session a week, 80 minutes per session. Home practice on alternate days for 20 minutes, 12 weeks	1. AC: Tai Chi 2. IC: Control group	Physical function: Lower and upper limb strength, lower and upper body flexibility, mobility HRQoL: Perceived physical and mental health, depression
(Oken et al., 2006) USA	N = 118 Mean age (SD): yoga group = 71.5 (4.9), exercise group = 73.6 (5.1), wait-list = 71.2 (4.4) years	Iyengar yoga, 1 class a week with home practice, 90 minutes per session, 24 weeks	1. AC: Walking group 2. IC: Wait-list control	Physical function: Lower body flexibility, lower limb strength, balance, walking speed HRQoL: Mood, fatigue, depression, perceived physical and mental health, pain, general health and well-being,

				social functioning, vitality
Saravanakumar et al. (2014) Australia	N = 33 Mean age (SD): 83.8 (7.9) years	Yoga, 2 times a week, 30 minutes per session, 14 weeks	1. AC: Tai Chi 2. IC: Usual care	Physical function: Balance, fall incidence, HRQol: Pain, quality of life.
Tew et al. (2017) UK	N = 47 Mean age (SD): 74.8 (7.2) years	British Wheel of Yoga Gentle Years Yoga programme, 10 sessions during a 12-week period, 75 minutes. Home practice encouraged for 10-20 minutes on most days, 12 weeks	1. IC: Wait-list control	Physical function: Body weight, BMI, waist circumference, lower limb strength, upper and lower body flexibility, balance, walking speed HRQoL: Perceived mental health, quality of life
Tiedemann et al. (2013) Australia	N = 52 Mean age (SD): 68 years (7.1) years	Iyengar yoga, 2 session a week, 60 minutes. Home practice 2 days a week for 10-20 minutes, 12 weeks	1. IC: Control group given fall prevention education booklet	Physical function: Balance, lower limb strength, walking speed HRQoL: Fear of falls
Vogler et al. (2011) Australia	N = 38 Mean age (SD): 73.21 (8.38) years	Iyengar yoga, 2 times per week, 90 minutes per session. Home practice 3 days per week for 15-20 minutes, 8 weeks	1. IC: Wait-list control group	Physical function: Muscle strength, range of motion of the upper extremity, hip flexion, hip extension, hip abduction, and trunk rotation HRQol: General health and well-being, perceived physical and mental health
Wang (2010) USA	N = 18 Mean age (SD): 74.9 (8.4) years	Yoga group, 2 times per week, 60 minutes per session, 4 weeks	1. IC: Social group	Physical function: Balance, lower limb strength, lower body flexibility HRQoL: Depression, morale, hope, social isolation

HRQoL: health related quality of life; BMI: Body Mass Index; AC: Active control; IC: Inactive control; N: Number of participants analysed in included studies

3.4.2 Intervention characteristics. Eight types of yoga (Table 10) were used in the studies including Hatha yoga (4 studies) (Gothe, 2013; Leininger, 2006; Morris, 2008; Nick et al., 2016), chair yoga (3 studies) (Bethany, 2005; Bonura & Tenenbaum, 2014; Marques et al., 2017), Iyengar yoga (3 studies) (Oken et al., 2006; Tiedemann et al., 2013; Vogler et al., 2011), Silver Yoga (2 studies) (Chen et al., 2008; Chen, Fan, et al., 2010), The Easy Does It Yoga Programme (2 studies) (Haber, 1983, 1988), Balance yoga programme (Ni, Mooney, Richards, et al., 2014), Thai Yoga (Noradechanunt et al., 2017) and the British Wheel of Yoga (BWY) Gentle Years Yoga programme (Tew et al., 2017). Five studies did not mention the type of yoga programme conducted (Bezerra et al., 2014; Hariprasad, Sivakumar, et al., 2013; Manjunath & Telles, 2005; Saravanakumar et al., 2014; Wang, 2010). The most common class structure for the yoga intervention adopted by included studies was a warm up, followed by the main postures, and ending with relaxation, breathing and meditation. Some common postures (used in four or more included studies) are: Cat and cow pose, Tree position, Triangle position, Seated twists, Mountain pose, Warrior 1, Cobra, Chair pose, Eagle or half eagle, Locust posture, Downward dog, Wind relieving pose, Child's Pose, Standing hands on feet pose, Cow face pose, Corpse pose (used for relaxation). The length of interventions ranged from four to 28 weeks, the most predominant being 24 weeks (6 studies) (Bonura & Tenenbaum, 2014; Chen et al., 2008; Chen, Fan, et al., 2010; Hariprasad, Sivakumar, et al., 2013; Manjunath & Telles, 2005; Oken et al., 2006) followed by 12 weeks (5 studies) (Bezerra et al., 2014; Ni, Mooney, Richards, et al., 2014; Noradechanunt et al., 2017; Tew et al., 2017; Tiedemann et al., 2013), and eight weeks (4 studies) (Gothe, 2013; Morris, 2008; Nick et al., 2016; Vogler et al., 2011). The most common frequency of intervention was two sessions per week (9 studies) (Leininger, 2006; Morris, 2008; Ni, Mooney, Richards, et al., 2014; Nick et al., 2016; Noradechanunt et al., 2017; Saravanakumar et al., 2014; Tiedemann et al., 2013; Vogler et al., 2011; Wang, 2010), followed by three sessions per week (6 studies) (Bethany, 2005; Bezerra et al., 2014; Chen et al., 2008; Chen, Fan, et al., 2010; Gothe, 2013; Haber, 1988). Eight studies also encouraged practicing yoga at home in addition to class based sessions (Haber, 1983; Hariprasad, Sivakumar, et al., 2013; Leininger, 2006; Noradechanunt et al., 2017; Oken et al., 2006; Tew et al., 2017; Tiedemann et al.,

2013; Vogler et al., 2011). Duration of classes ranged from 30 minutes to 90 minutes. A 60 minute class duration was reported most frequently (9 studies) (Haber, 1988; Hariprasad, Sivakumar, et al., 2013; Leininger, 2006; Manjunath & Telles, 2005; Morris, 2008; Ni, Mooney, Richards, et al., 2014; Nick et al., 2016; Tiedemann et al., 2013; Wang, 2010). One study did not report class duration (Haber, 1983). Inactive controls used in the studies were wait-list control (8 studies) (Bonura & Tenenbaum, 2014; Chen et al., 2008; Chen, Fan, et al., 2010; Hariprasad, Sivakumar, et al., 2013; Manjunath & Telles, 2005; Oken et al., 2006; Tew et al., 2017; Vogler et al., 2011), playing games like Dominoes, Chinese Checkers and Scrabble (Bethany, 2005), fall risk awareness (Morris, 2008), socialisation (Wang, 2010), education on osteoporosis and fitness (Leininger, 2006), fall prevention education booklet (Tiedemann et al., 2013), herbal preparation (Manjunath & Telles, 2005), telephone counselling (Noradechanunt et al., 2017), film series or art class (Haber, 1983), and usual care where no intervention was provided but participants could continue to use the facilities provided by the residential care centre like bingo, story-telling, exercise classes and gym (Saravanakumar et al., 2014). Active controls included were Tai Chi (3 studies) (Ni, Mooney, Richards, et al., 2014; Noradechanunt et al., 2017; Saravanakumar et al., 2014), chair aerobics/exercise (2 studies) (Bethany, 2005; Bonura & Tenenbaum, 2014), a walking programme (2 studies) (Bethany, 2005; Oken et al., 2006), balance training (2 studies) (Morris, 2008; Ni, Mooney, Richards, et al., 2014), and stretching–strengthening exercises (Gothe, 2013).

Table 10

Types of yoga used in included studies

Types of yoga in included studies (number of studies, total number of participants)	Description
The types of yoga used in studies are similar in structure and postures, and their main features are highlighted below.	
Hatha yoga (4 studies, 247 participants)	Traditional yoga that includes combinations of postures, breathing, and meditation (McCall, Ward, Roberts, & Heneghan, 2013).
Chair yoga (3 studies, 165 participants)	This essentially follows a traditional Hatha yoga format, but is modified so that chairs are used during practice to accommodate physical limitations (Bonura & Tenenbaum, 2014).
Iyengar yoga (3 studies, 208 participants)	Created by BKS Iyengar; based on Hatha yoga, but emphasis is on strength, balance, and use of props. Usually involves slow movement and holding poses (McCall et al., 2013).
Silver Yoga (2 studies, 231 participants)	The programme is based on Hatha yoga and Raja yoga (type of yoga that focuses on concentration and meditative techniques). The programme includes gentle stretching postures to increase range of motion and progressive muscle relaxation. Special consideration given for the physical abilities and tolerance of older adults (Chen et al., 2007).
Balance yoga programme (1 study, 39 participants)	This programme is based on a study by the authors showing specific muscle utilization patterns during different flow-based yoga poses. The programme has three levels of difficulty, becoming progressively challenging (Ni, Mooney, Richards, et al., 2014).
The Easy Does It Yoga Programme (2 studies, 496 participants)	Yoga programme designed for older adults (Haber, 1988).
Thai Yoga (1 study, 33 participants)	Thai Yoga is similar to the Hatha yoga style. However, it is less strenuous and incorporates postures that are less challenging and easier to perform than those of Hatha yoga (Noradechanunt et al., 2017).
British Wheel of Yoga (BWY) Gentle Years Yoga programme (1 study, 47 participants)	The British Wheel of Yoga (BWY) Gentle Years Yoga programme was developed to cater to the needs of older people with age-related conditions (osteoarthritis, hypertension, dementia, and sensory impairment). Hatha yoga poses were adapted so that older adults with comorbidities and physical limitations could safely participate (Tew et al., 2017).

3.4.3 Results of vote counting. The vote-counting tables with all results for both physical function and HRQoL outcomes are presented in the supplementary section (Appendix 6).

3.4.3.1 Physical function. For yoga vs inactive controls, the "favouring yoga" category received most votes for the following outcomes (presented as: number of results where yoga has significantly positive effects compared with control / total

number of results): cardio-respiratory fitness (2/3), flexibility (17/23, with lower body flexibility (5/7), ROM (10/13), upper body flexibility (2/3)), and walking speed (3/5). On no occasion did the inactive controls group receive more votes than yoga.

While comparing yoga and active controls, the "no significant difference" category got the highest number of votes for all outcomes.

3.4.3.2 HRQoL. For yoga vs inactive controls, the "favouring yoga" category received most votes for the following outcomes: quality of life (2/3), and sleep quality (3/4). In the yoga vs active controls analysis, the "favouring yoga" category did not receive the highest number of votes for any of the outcomes. The "favouring control" category received no votes for both yoga vs active and yoga vs inactive controls for any HRQoL outcomes.

3.4.4 Results of Meta-analysis. Sixteen studies assessing physical function and 17 assessing HRQoL variables (from 18 records) were included in the meta-analysis (Table 11). Data used for meta-analysis are attached as supplementary tables (Appendix 7).

3.4.4.1 Physical function

(i) Yoga vs Inactive controls. Yoga was found to significantly improve balance (ES (Hedges' g) = 0.7, 95% CI 0.19 to 1.22, p = 0.01), lower limb strength (ES = 0.45, 95% CI 0.22 to 0.68, p<0.001), and lower body flexibility (ES = 0.50, 95% CI 0.30 to 0.69, p<0.001) compared to inactive controls (Figure 12). No significant difference between yoga and inactive controls was found for body composition (ES = 0.16, 95% CI -0.06 to 0.38, p = 0.16), upper body flexibility (ES = 0.28, 95% CI -0.02 to 0.58, p = 0.07) or walking speed (ES = 0.38, 95% CI -0.02 to 0.78, p = 0.06).

(ii) Yoga vs Active controls. There was a significant effect favouring yoga for lower limb strength (ES = 0.49, 95% CI 0.10 to 0.88, p = 0.01) and lower body flexibility (ES = 0.28, 95% CI 0.01 to 0.54, p = 0.04) (Figure 13). No significant

difference between yoga and active controls was found for balance (ES = 0.32, 95% CI -0.02 to 0.66, p = 0.07), mobility (ES = 0.31, 95% CI -0.25 to 0.87, p = 0.28) or walking speed (ES = -0.29, 95% CI -0.79 to 0.22, p= 0.26).

3.4.4.2 HRQoL

(i) Yoga vs. Inactive controls. There was a significant effect favouring yoga for depression (ES = 0.64, 95% CI 0.32 to 0.95, p<0.001), perceived mental health (ES = 0.60, 95% CI 0.33 to 0.87, p<0.001), perceived physical health (ES = 0.61, 95% CI 0.29 to 0.94, p<0.001), sleep quality (ES = 0.65, 95% CI 0.41 to 0.88, p<0.001), and vitality (ES = 0.31, 95% 0.03 CI to 0.59, p = 0.03) (Figure 14). No significant effect was found for fear of falls (ES = 0.39, 95% CI -0.45 to 1.24, p = 0.36) or social health (ES = 0.27, 95% CI -0.15 to 0.69, p = 0.20).

(ii) Yoga vs. Active controls. A significant effect favouring yoga was found for depression (ES = 0.54, 95% CI 0.25 to 0.83, p<0.001) (Figure 15). No significant effect was found for anxiety (ES = 0.43, 95% CI -0.03 to 0.88, p = 0.06) and perceived mental health (ES = 0.26, 95% CI -0.03 to 0.55, p = 0.08).

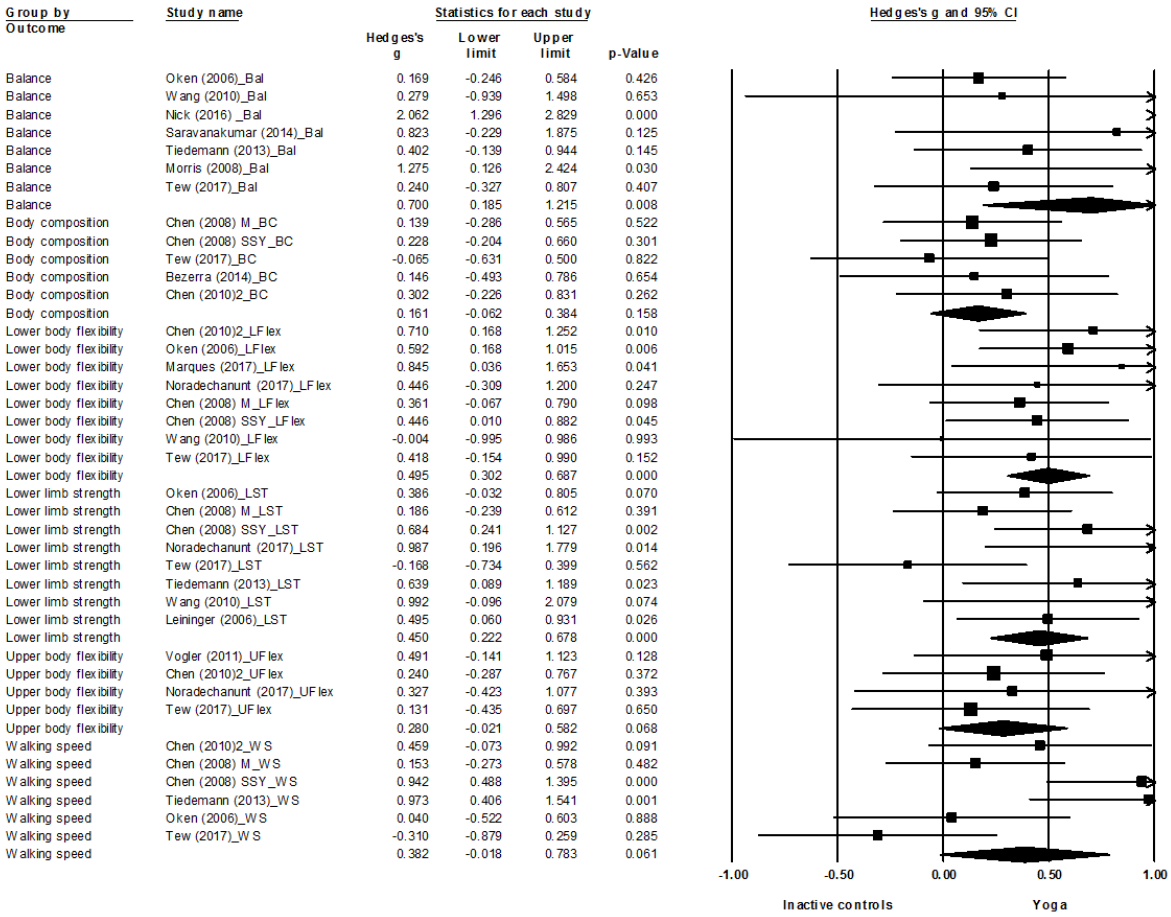


Figure 12. Effect sizes and 95% confidence intervals for yoga compared to inactive controls on physical function outcomes
Balance; M: Yoga group with meditation; SSY: Short Silver Yoga; BC: Body composition; LFlex: Lower body flexibility; LST: Lower limb strength; UFlex: Upper body flexibility; WS: Walking speed

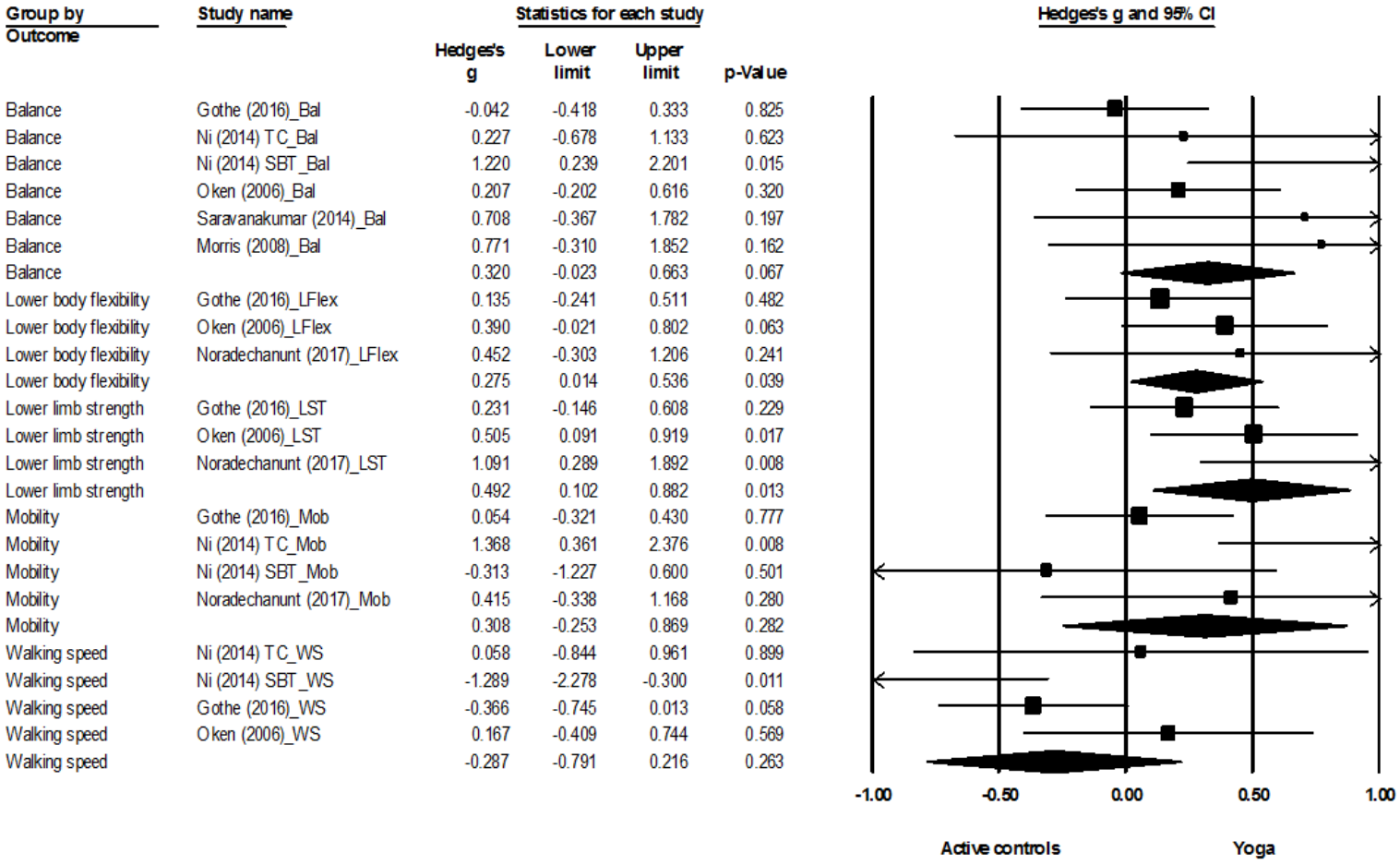


Figure 13. Effect sizes and 95% confidence intervals for yoga compared to active controls on physical function outcomes
Legend: Bal: balance; TC: Tai Chi; SBT: Standard balance training; LFlex: Lower body flexibility; LST: Lower limb strength; Mob: Mobility; WS: Walking speed

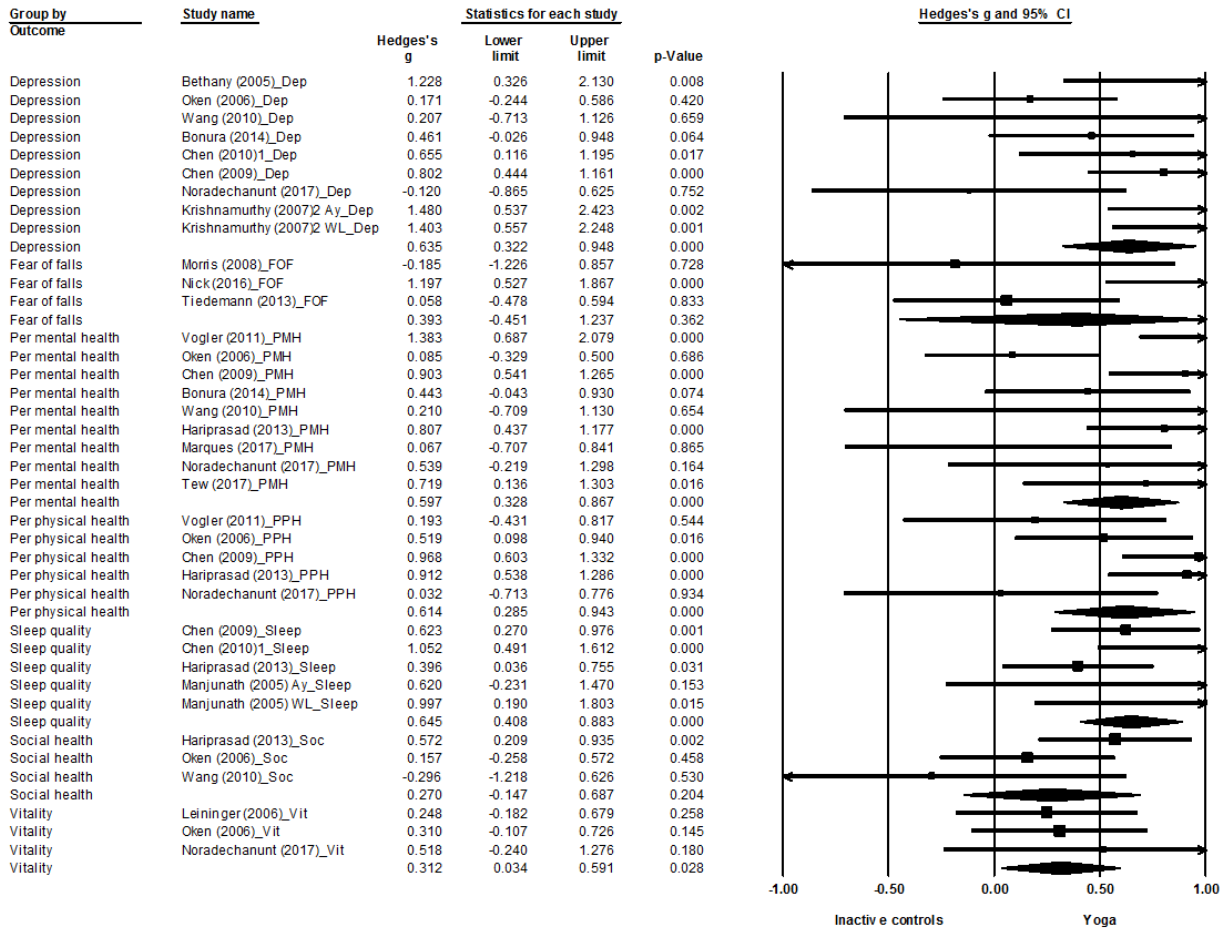


Figure 14. Effect sizes and 95% confidence intervals for yoga compared to inactive controls on HRQoL outcomes
Dep: Depression; FOF: Fear of falls; Per mental health/PMH: Perceived mental health; Per physical health/PPH: Perceived physical health; Sleep: Sleep quality; Soc: Social health; Vit: Vitality; Ay: Ayurveda (herbal preparation); WL: Wait-list control

Group by Outcome	Study name	Statistics for each study			
		Hedges's g	Lower limit	Upper limit	p-Value
Anxiety	Bonura (2014)_Anx	0.339	-0.142	0.819	0.167
Anxiety	Bethany (2005) CA_Anx	1.097	0.084	2.111	0.034
Anxiety	Bethany (2005) W_Anx	1.041	-0.036	2.118	0.058
Anxiety	Gothe (2013)_Anx	0.043	-0.333	0.419	0.822
Anxiety		0.426	-0.025	0.876	0.064
Depression	Bethany (2005) CA_Dep	1.317	0.274	2.360	0.013
Depression	Bethany (2005) W_Dep	0.791	-0.259	1.840	0.140
Depression	Oken (2006)_Dep	0.545	0.129	0.960	0.010
Depression	Bonura (2014)_Dep	0.526	0.041	1.012	0.033
Depression	Noradechanunt (2017)_Dep	0.000	-0.744	0.744	1.000
Depression		0.538	0.247	0.829	0.000
Per mental health	Oken (2006)_PMH	0.320	-0.090	0.731	0.126
Per mental health	Noradechanunt (2017)_PMH	0.366	-0.385	1.117	0.340
Per mental health	Bonura (2014)_PMH	0.133	-0.345	0.610	0.586
Per mental health		0.259	-0.029	0.546	0.078

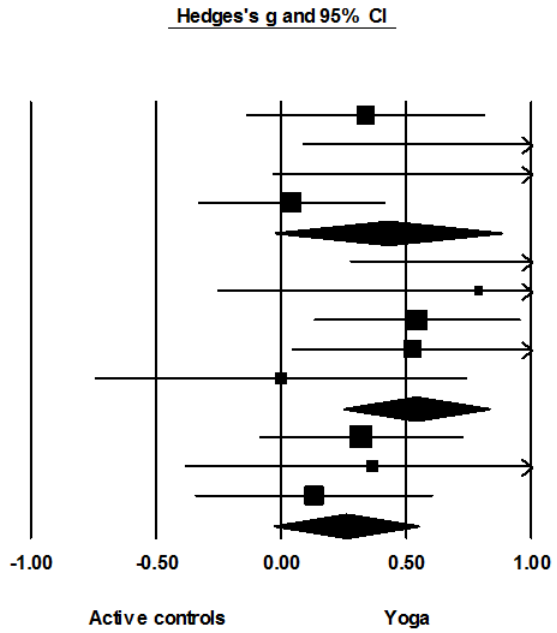


Figure 15. Effect sizes and 95% confidence intervals for yoga compared to active controls on HRQoL outcomes
Legend: Anx: Anxiety; CA: Chair aerobics; W: Walking programme; Dep: Depression; Per mental health/PMH: Perceived mental health

Table 11. Meta-analysis results- effect sizes and heterogeneity

Outcome	No. of studies	Total number of participants	Effect size		Heterogeneity	
			Hedges' g (95% CI)	P-value	I^2	P-value
Physical function - Yoga vs inactive controls						
Balance	7	265	**0.70 (0.19 to 1.22)**	**0.01**	72.15	0.001
Body composition	4	314	0.16 (-0.06 to 0.38)	0.16	0.00	0.91
Lower body flexibility	7	431	**0.50 (0.3 to 0.69)**	**<0.001**	0.00	0.88
Lower limb strength	7	485	**0.45 (0.22 to 0.68)**	**<0.001**	32.70	0.17
Upper body flexibility	4	166	0.28 (-0.02 to 0.58)	0.07	0.00	0.87
Walking speed	5	377	0.38 (-0.02 to 0.78)	0.06	72.69	0.003
Physical function - Yoga vs active controls						
Balance	5	264	0.32 (-0.02 to 0.66)	0.07	34.74	0.18
Lower body flexibility	3	225	**0.28 (0.01 to 0.54)**	**0.04**	0.00	0.59
Lower limb strength	3	225	**0.49 (0.1 to 0.88)**	**0.01**	47.44	0.15
Mobility	3	173	0.31 (-0.25 to 0.87)	0.28	58.73	0.06
Walking speed	3	192	-0.29 (-0.79 to 0.22)	0.26	57.41	0.07
HRQoL - Yoga vs inactive controls						
Depression	8	450	**0.64 (0.32 to 0.95)**	**<0.001**	57.09	0.02
Fear of falls	3	104	0.39 (-0.45 to 1.24)	0.36	75.64	0.02
Perceived mental health	9	554	**0.6 (0.33 to 0.87)**	**<0.001**	54.87	0.02
Perceived physical health	5	400	**0.61 (0.29 to 0.94)**	**<0.001**	58.55	0.05
Sleep quality	4	353	**0.65 (0.41 to 0.88)**	**<0.001**	13.06	0.33
Social health	3	225	0.27 (-0.15 to 0.69)	0.2	51.76	0.13
Vitality	3	196	**0.31 (0.03 to 0.59)**	**0.03**	0.00	0.83
HRQoL - Yoga vs active controls						
Anxiety	3	206	0.43 (-0.03 to 0.88)	0.06	50.03	0.11
Depression	4	215	**0.54 (0.25 to 0.83)**	**<0.001**	8.61	0.36
Perceived mental health	3	183	0.26 (-0.03 to 0.55)	0.08	0.00	0.81

CI: Confidence interval; Significant effect sizes (95% CI) and corresponding p values have been highlighted in bold

3.4.5 Heterogeneity. Statistically significant heterogeneity was found only when comparing yoga and inactive controls (Table 11). For physical function, significant substantial heterogeneity was found for balance ($I^2 = 72.15$, $p = 0.001$), and walking speed ($I^2 = 72.69$, $p = 0.003$). For HRQoL outcomes, statistically significant considerable heterogeneity was found for fear of falls ($I^2 = 75.64$, $p = 0.02$). Significant substantial heterogeneity was found for depression ($I^2 = 57.09$, $p = 0.02$), perceived mental health ($I^2 = 54.87$, $p = 0.02$), and perceived physical health ($I^2 = 58.55$, $p = 0.05$). Combining data from different measurement instruments could introduce heterogeneity. For example, significant heterogeneity arose in the comparison of yoga and inactive when balance data from one-leg-stand test, Berg balance scale, standing balance tests and POMA were combined. In contrast, when lower body flexibility was measured using a single instrument (sit-and-reach/chair sit-and-reach test) no significant heterogeneity occurred.

3.4.6 Sensitivity analyses and cluster randomisation adjustment. Sensitivity analyses were conducted for four studies which had two controls, introducing one full control arm and then the other (Appendix 8). For one study (Ni, Mooney, Richards, et al., 2014), yoga was compared with active controls, and the sensitivity analysis affected three outcomes (balance, mobility and walking speed). For the second study (Bethany, 2005), yoga was compared to active controls affecting two HRQoL outcomes (anxiety and depression). The third study (Manjunath & Telles, 2005) and fourth study (Krishnamurthy & Telles, 2007b) compared yoga with inactive controls and the sensitivity analysis affected sleep quality (Manjunath & Telles, 2005) and depression (Krishnamurthy & Telles, 2007b). While there were small changes in effect sizes and p values, none of the variables crossed the significance thresholds, and conclusions derived from the original analysis were not altered.

Meta-analysis results were not greatly altered after taking into account cluster randomization (Appendix 9). While there was a small reduction in effect sizes for some outcomes, significance was not affected.

3.4.7 Risk of bias. For physical function, relatively few studies had high risk of bias (selection bias: random sequence generation (6%) and allocation concealment (18%), detection bias (6%), attrition bias (24%), reporting bias (18%) and other bias (41%)) (Figure 16). Sample selection bias was evident for many studies and a small number were also at risk of contamination bias. Similarly, only few studies assessing HRQoL outcomes had high risk of bias (selection bias: random sequence generation (5%) and allocation concealment (10%), detection bias (10%), attrition bias (24%) and reporting bias (5%)) (Figure 17). Other bias included response bias which emanates from the use of questionnaires and interviews, including social desirability response, acquiescence response and Hawthorne effect (Furnham, 1986). Since all studies assessing HRQoL used subjective self-report instruments, the risk of other bias is 100% for HRQoL outcomes. Detailed information on sources of bias is provided as supplementary material (Appendix 10).

Study id	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective outcome reporting (reporting bias)	Other bias
Bezerra (2014)	Unclear	Unclear	Unclear	Unclear	Low	Unclear
Chen (2008)	Unclear	Unclear	Unclear	Low	High	High
Chen (2010)2	Unclear	High	Unclear	Low	High	High
Gothe (2016)	Unclear	Unclear	Unclear	Low	Low	Low
Krishnamurthy (2007)	Unclear	Unclear	Unclear	High	High	Unclear
Leininger (2006)	High	High	Low	Low	Low	High
Marques (2017)	Low	Low	Unclear	High	Low	Low
Morris (2008)	Unclear	Unclear	Unclear	High	Low	High
Ni (2014)	Unclear	Unclear	Unclear	High	Low	High
Nick (2016)	Low	High	High	Low	Low	Low
Noradechanunt (2017)	Low	Low	Low	Low	Low	Low
Oken (2006)	Low	Low	Low	Low	Low	Low
Saravanakumar (2014)	Low	Low	Low	Low	Low	Low
Tew (2017)	Low	Low	Low	Low	Low	High
Tiedemann (2013)	Low	Low	Low	Low	Low	Low
Vogler (2011)	Unclear	Unclear	Unclear	Low	Low	High
Wang (2010)	Unclear	Unclear	Unclear	Unclear	Low	Low

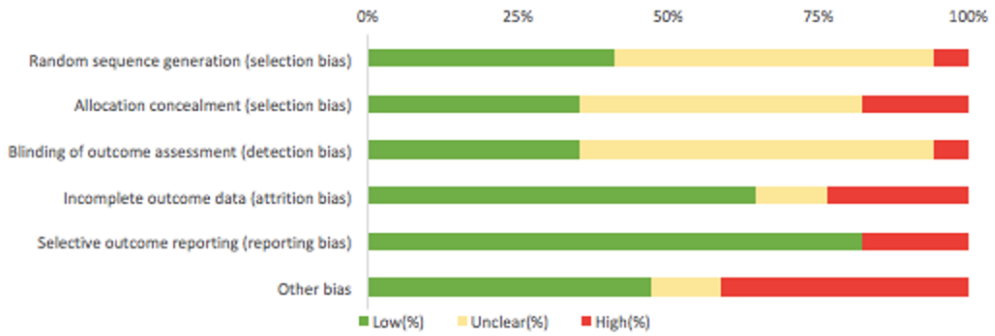


Figure 16. Risk of bias table and graph for physical function outcomes

Study id	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective outcome reporting (reporting bias)	Other bias
Bethany (2005)	Unclear	Unclear	Unclear	Low	Low	High
Bonura (2014)	Unclear	Unclear	Unclear	Low	Low	High
Chen (2009)	Low	Unclear	Unclear	Low	Low	High
Chen (2010)1	Unclear	Unclear	Unclear	Low	Low	High
Gothe (2013)	Unclear	Unclear	Unclear	Low	Low	High
Haber (1983)	Unclear	Unclear	Unclear	High	Unclear	High
Haber (1988)	Unclear	Unclear	Unclear	Unclear	Low	High
Hariprasad (2013)	Unclear	Low	Unclear	Low	Low	High
Krishnamurthy (2007)2	Low	Low	Unclear	High	Low	High
Leininger (2006)	High	High	Low	Low	Low	High
Manjunath (2005)	Low	Low	Low	High	Low	High
Marques (2017)	Low	Low	Unclear	High	Low	High
Morris (2008)	Unclear	Unclear	Unclear	High	Low	High
Nick (2016)	Low	High	High	Low	Low	High
Noradechanunt (2017)	Low	Low	Low	Low	Low	High
Oken (2006)	Low	Low	Low	Low	High	High
Saravanakumar (2014)	Low	Low	High	Low	Low	High
Tew (2017)	Low	Low	Low	Low	Low	High
Tiedemann (2013)	Low	Low	Low	Low	Low	High
Vogler (2011)	Unclear	Unclear	Unclear	Low	Low	High
Wang (2010)	Unclear	Unclear	Unclear	Unclear	Low	High

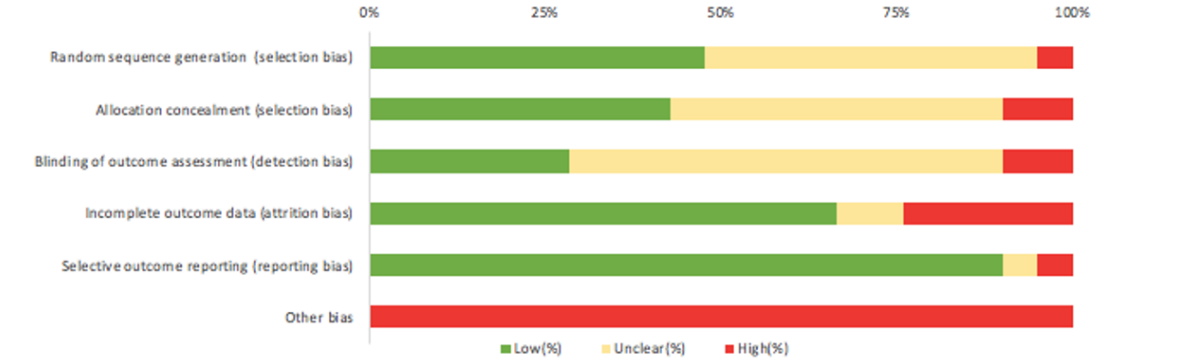


Figure 17. Risk of bias table and graph for HRQoL outcomes

3.5 Discussion

3.5.1 Summary of main findings. The results of this systematic review demonstrate that compared to inactive controls, it is possible for older adults to improve many aspects of their physical function and HRQoL through participating in a yoga intervention. Findings suggest that small to moderate sized beneficial effects can be achieved for balance, lower body flexibility, lower limb strength, depression, perceived mental health, perceived physical health, sleep quality, and vitality. When yoga was compared with active controls, statistically significant small to moderate effects favouring yoga were found for lower body strength, lower body flexibility and depression. Yoga was found to be as good as the activity undertaken by active controls in improving outcomes such as mobility, walking speed, balance, anxiety and perceived mental health. The yoga group was never significantly worse than the active or inactive group for any of the outcomes. With high attendance rates for class-based sessions, yoga is a feasible intervention that can be recommended to older adults as an activity that improves physical and mental wellbeing.

3.5.2 Comparison to previous literature. While other systematic reviews have included, or focused on, studies that recruited older adults with clinical conditions, this review is the first to provide a comprehensive overview of the effects of yoga on physical function and HRQoL in an older adult population not characterised by a specific disease or condition. Outcomes such as depression, perceived mental and physical health, balance and mobility have been evaluated by other meta-analysis of RCTs in an older adult population (Table 12), and are described in the section below.

3.5.2.1 Physical function. Youkhana et al. (2016) conducted a systematic review to assess the effects of yoga on balance and mobility. Since the control groups in the review consisted of no intervention, waitlist control/usual care and provision of an education booklet, the study results can be contrasted with the inactive controls groups of the present study. Although the direction of the effect for balance is similar between the two reviews, the effect size in the inactive control group in this study is much higher than in the Youkhana et al. review (Table 12). The

meta-analysis for balance in their review included six studies, with three studies in common with the inactive control group. The difference in effect size could be because of the extremely high effect size in one study included only in the current review, in which participants with poor balance were recruited, and saw great benefits from the yoga intervention (Nick et al., 2016). Heterogeneity was lower and non-significant in their review for balance compared to the inactive control group in the current study. This could be attributed to more variation in the yoga types, as well as the inclusion of participants with poor balance at base-line in the current review.

The two reviews used different tests to assess mobility. Hence, a meta-analysis was conducted for mobility in the review by Youkhana et al. (Youkhana et al., 2016), but not in the current review while comparing yoga with inactive controls. The current study assessed mobility using the timed-up-and-go test (Appendix 11), which was measured only by two studies, and hence no meta-analysis was conducted. In the meta-analysis by Youkhana et al. (Youkhana et al., 2016), mobility was measured in three studies using the timed-eight-foot-walk, sit-to-stand test and the 4-metre-walk. Two of the three studies (Oken et al., 2006; Tiedemann et al., 2013) were also included in the current review, with the sit-to-stand test included under strength and the 4-metre-walk included under walking speed (Appendix 11).

3.5.2.2 HRQoL. Two reviews conducted meta-analyses to assess the effects of yoga on perceived mental and physical health in older adults (Patel et al., 2012; Tulloch et al., 2018), and found a significant positive effect favouring yoga.

A smaller effect size was found for these outcomes in the Tulloch et al. review (Tulloch et al., 2018) compared to the current study (Table 12). The effect size in the present study for perceived physical and mental health in the inactive control group can be compared to HRQoL and mental wellbeing in the meta-analysis by Tulloch et al. correspondingly. The smaller effect size may be attributed to differences in inclusion criteria (studies which specifically recruited clinical populations were excluded in the current study), and only four of the 12 studies in

the Tulloch et al. meta-analysis overlapped with the inactive control group of the present study. Some studies included in the current review (Vogler et al., 2011; Wang, 2010) were not captured by the Tulloch review due to differing search strategies, and search dates. The effect sizes for perceived physical and mental health in the meta-analysis by Patel et al. (Patel et al., 2012) were comparable to that of the inactive control group in the current study. Their review also assessed depression, and although a moderate effect size was found, it was not significant. The current meta-analysis for depression included more studies and may have the power to detect differences between groups. In line with the results of the current review, another systematic review published in Chinese (Wang et al., 2014) concluded that yoga significantly reduced depressive symptoms and improved quality of sleep in older adults.

Table 12

Comparison of effect sizes from previous reviews and the current review

SMD:

Outcome	Study	Effect size in comparator review	Effect size present review	Notes
Balance	Youkhana et al. (2016)	Hedges' g = 0.40, 95% CI 0.15 to 0.65. I^2 = 0.00%, P = 0.615	Inactive controls: Hedges' g = 0.70, 95% CI 0.19 to 1.22. I^2 = 72.15, P = 0.001	Larger effect size in current review may be attributed to inclusion of a RCT (Nick et al., 2016) which recruited participants with poor balance at baseline.
Mobility	Youkhana et al. (2016)	Hedges' g = 0.50, 95% CI 0.06 to 0.95. I^2 = 51.8%, P = 0.126	Inactive controls: No meta-analysis for mobility	Mobility assessed by timed-up-and-go test in the current review (measured by only 2 studies). Mobility measured in Youkhana et al. (2016) by three studies using the timed-eight-foot-walk, sit-to-stand test and the 4-metre-walk.
Perceived mental health	Tulloch et al. (2018)	Hedges' g = 0.38, 95% CI 0.15 to 0.62. I^2 = 56.3%, P = 0.009	Inactive controls: Hedges' g = 0.6, 95% CI 0.33 to 0.87. I^2 = 54.87, P = 0.02	Larger effect size in current review may be attributed to differences in inclusion criteria, differing search strategies, and search dates.
	Patel et al. (2012)	SMD = 0.66, 95% CI 0.10 to 1.22. I^2 = 77%		Comparable effect size.
Perceived physical health	Tulloch et al. (2018)	Hedges' g = 0.51, 95% CI 0.25 to 0.76. I^2 = 62.9%, P = 0.002	Inactive controls: Hedges' g = 0.61, 95% CI 0.29 to 0.94. I^2 = 58.55, P = 0.05	Larger effect size in current study may be attributed to differences in inclusion criteria, differing search strategies, and search dates.
	Patel et al. (2012)	SMD = 0.65, 95% CI 0.02 to 1.28. I^2 = 82%		Comparable effect size.
Depression	Patel et al. (2012)	SMD = - 0.57, 95% CI - 1.17 to 0.04. I^2 = 80% (The negative effect size here indicates that yoga reduces depression scores to a greater extent than comparison groups)	Inactive controls: Hedges' g =.64, 95% CI 0.32 to 0.95. I^2 = 57.09, P = 0.02	Inclusion of more RCTs may have increased the power to detect differences between groups, producing significant effects favouring the yoga group in the current study.

Standardised Mean Difference; CI: Confidence Interval

3.5.3 Strengths and limitations. This systematic review and meta-analysis offers a comprehensive view of the effectiveness of yoga on both physical and psychological outcomes. The method of segregating controls into active and inactive

groups has not been adopted by any other systematic review for this age group, and is a significant strength of this study. The review provides novel and valuable information on the effects of yoga on some salient outcomes like strength, vitality, and social health in an older adult population. No yoga RCT has directly assessed strength in older adults using techniques like isokinetic dynamometry (gold standard) or hand-held dynamometry (Stark, Walker, Phillips, Fejer, & Beck, 2011). To our knowledge this is the first study to conduct a meta-analysis to comment on the effectiveness of yoga in improving strength albeit using a functional fitness measure as a proxy (sit-to-stand test). The sit-to-stand test is a reliable and valid indicator of lower body strength in older adults (Jones, Rikli, & Beam, 1999). Used in conjunction with measures of flexibility, balance, mobility and walking speed, the sit-to-stand test is a fitting indicator of functional fitness and the ability to perform everyday activities in older adults (Rikli & Jones, 1999).

This study had a broad search strategy, and criteria other than yoga and older adults were applied only at the screening stage, making it less likely to miss out studies. The review also included dissertations, which were not included in some previous reviews (Patel et al., 2012), leading to more robust results. However, the authors had difficulties in securing quantitative data for non-significant outcomes for some included studies (selective reporting bias) (Chen et al., 2008; Chen, Fan, et al., 2010), and these could not be incorporated in the meta-analysis. Consideration of this bias is critical since the primary studies test numerous outcomes, increasing the chance of type 2 errors. The inclusion of articles only published in English can be considered a limitation of the review. However, the review has captured studies from across the world including non-English speaking countries such as India, Taiwan, Brazil, and Iran. Only three studies (Saravanakumar et al., 2014; Tew et al., 2017; Tiedemann et al., 2013) actually included adverse events as an outcome at the onset of the intervention. While eight studies reported on adverse events in the yoga group, it is not evident if there were no adverse events in the other studies, or if they were not reported. In one study (Morris, 2008) it is not clear if the injuries reported can be attributed to the yoga intervention. Ambiguous or no reporting of adverse events is a deficiency in yoga research, which future studies should address. While only a small

proportion of included studies have been rated as high risk of bias, several studies have unclear risk of bias for random sequence generation, allocation concealment and blinding of outcome assessment. Future studies should ensure that randomisation and data collection procedures are reported in detail to allow for accurate assessment of bias and reliability of intervention effects.

The classification of test and instruments into broad physical function and HRQoL categories was carried out in a structured manner, referring to literature when available to support the decisions made. However, this process can be subjective, and could be the root of differences in effect sizes between reviews (for example, sit-to-stand test was classified as assessing mobility in the Youkhana et al. review (Youkhana et al., 2016), but was categorised as evaluating lower limb strength in the present review).

3.5.4. Implications for policy and practice. The study offers clear evidence that compared to no activity, yoga improves physical function and psychological wellbeing in older adults. It can be inferred from the meta-analysis results that yoga improves muscle strength and balance. Previous systematic reviews have highlighted the potential of yoga in improving balance in healthy adults (Jeter et al., 2014), and PA policy should continue to promote yoga within muscle strength and balance guidelines to enhance and maintain health. Approximately 15% of older adults are likely to suffer from a mental health disorder (World Health Organization, 2017), with depression affecting 22% of older men and 28% of older women in the UK (Craig & Mindell, 2007). Mental wellbeing is critical for an older adult population, and this review highlights the beneficial effects of yoga in improving perceived physical and mental health, vitality, and alleviating depressive symptoms.

The findings from this review could be used to challenge older adults' perceptions of yoga. Older adults have the impression that yoga only improves flexibility, and the lack of an aerobic component has been cited as a barrier to yoga participation (Sivaramakrishnan, Fitzsimons, Mutrie, & Baker, 2017). The older population and yoga teachers need to be educated on the muscle strength and balance

guidelines, and also made aware of the physical function and HRQoL benefits of yoga as evidenced by this study. Information from the studies included in this review (e.g. common yoga postures and class structure) should be shared with yoga teachers. Although not directly examined in relation to effectiveness, the cross tabulation of frequency and duration of class-based sessions (Appendix 12) showed that 60 minutes on two days a week was the most common, which can be easily translated to practice.

Yoga is a recognised and accepted form of activity in India where it originated. In western countries, although an increasing trend in older adult participation in yoga/pilates has been observed (Currie, 2017; Gill, 2015; Vergeer et al., 2017), yoga participation rates still remain low (Cramer et al., 2016; Ding & Stamatakis, 2014; Gill, 2015). This review adds to the growing evidence on the benefits of yoga, and researchers should work closely with yoga teachers, studios, fitness centres and policy makers to develop and implement strategies to encourage yoga participation among older adults, tying in with the final aim of increasing participation in muscle strength and balance activities.

3.5.5 Future research. Future intervention studies should include an active control arm, so that conclusions can be drawn with respect to the effectiveness of yoga compared to different exercise programmes. Upper limb strength, hand grip strength, fall frequency, balance confidence, stress and self-efficacy are relevant and important outcomes for this population. The effects of yoga on these outcomes could not be computed through a meta-analysis due to lack of studies, and future research with robust experimental designs should focus on these outcomes. Future systematic reviews for the older adult population should aim to comment on dose-response relationships. The current review assessed the effects of yoga immediately after the intervention, and 28-weeks was the longest follow-up period. Future reviews should assess effects over a longer period, taking into account post-intervention follow-up data. Moreover, this review did not include physiological (e.g. cholesterol, indicators of immune function) and cognitive outcomes (e.g. memory and executive functions) and future reviews could aim to assess these outcomes.

There is a need to develop an appropriate framework for assessing physical function in an older adult population. Health Related Physical Fitness is defined in the American College of Sports Medicine manual as consisting of those specific components of physical fitness that have a relationship with good health, and includes cardio-respiratory fitness, body composition, muscular strength and flexibility (Kaminsky, 2010). However, it does not include mobility, walking speed, balance and frequency of falls which are important parameters of health for this population. Moreover, clear guidance is needed on the tests and instruments that assess these aspects, with details on whether they are a valid measure of the outcomes assessed. A study may have more than one instrument assessing the same outcome, and there is no standard procedure for choosing which one measure to include in the meta-analysis. This is a potential source of bias, and guidance for this process should be developed to reduce subjectivity.

3.6 Conclusion

Results of this systematic review and meta-analysis show that yoga improves multiple physical function and HRQoL outcomes in older adults not characterised by any specific disease or condition. Compared to inactive controls, small to moderate significant effects favouring yoga were found for balance, lower body flexibility, lower limb strength, depression, perceived mental health, perceived physical health, sleep quality, and vitality. When yoga was compared with active controls, significant small to moderate effects were also found for lower body strength, lower body flexibility and depression. Yoga is a multimodal activity that improves muscle strength, balance and flexibility in older adults, and physical activity policy should continue to promote yoga as an activity that enhances physical and mental wellbeing in this population.

3.7 Additional Information

Table 13 depicts the steps followed during the course of the systematic review.

Table 13

Steps in the systematic review process

Steps	Systematic review process
Step 1	Defining PICOS (Population; Intervention/Control; Outcome; Study), search and screening criteria
Step 2	Registering on Prospero database (International prospective register of systematic reviews)
Step 3	Database searching
Step 4	Screening and selection
Step 5	Data extraction
Step 6	Mapping instruments/tests to broad physical function and health related quality of life outcomes
Step 7	Vote-counting analysis
Step 8	Meta-analysis including sensitivity analysis and cluster randomisation adjustment
Step 9	Risk of bias analysis
Step 10	Interpretation of results

All steps except for Step 6 have been discussed in the manuscript attached, and supporting data and documents have been provided as appendices. Step 6 was not covered in the manuscript due to space constrains. This step involved mapping the tests and instruments used in included studies to broad physical function and HRQoL outcomes, based on available literature. References for this analysis were publications, reports and databases describing the test/instrument, its purpose and protocol. Tables with the instruments and tests measuring each outcome, along with relevant references used in the classification process are presented as supplementary data for physical function (Appendix 13) and HRQoL (Appendix 14) outcomes.

3.8 Identifying Recently Published Studies Relating to Yoga for Older Adults

This section describes an exercise undertaken with the aim of identifying and reporting on the most recent RCTs and reviews pertaining to yoga for older adults. In

the published manuscript, the database searches were conducted in September 2017. To identify recent studies published after the search date for the review and satisfying the inclusion criteria, a further database search was conducted in October 2018. The Medline database was searched using the same search terms as the initial search (September 2017), with time limits applied (2017 to current date). One hundred and seven studies were identified. Three additional search terms (not used in the original search) were then used to identify RCTs (Randomized Controlled Trials as Topic/ or Randomi#ed control* trial$ or RCT$), which yielded 35 studies. The RCT criteria was used during the screening phase while conducting the systematic review, but was used as a search term for this exercise to reduce time and effort spent on screening. Screening the title and abstract of the 35 studies revealed that none satisfied the study inclusion criteria. No new RCTs satisfying the systematic review criteria were identified from an updated Medline search.

Next, the 107 studies were limited to review articles, and this yielded 19 review articles. One review addressed yoga for an older adult population. Mooventhan and Nivethitha (2017) reviewed the effects of yoga practice on health related problems of the elderly. The review concluded that yoga was effective in improving outcomes such as heart rate, blood pressure, blood glucose, oxidative damage, fatigue, weakness, fear of fall, heart rate variability, baroreflex sensitivity, insulin sensitivity, physical functions, mobility, flexibility, and urinary incontinence in older adults. Psychological benefits were also reported such as self-efficacy, vitality, quality of sleep, quality of life, and reduced depression, anxiety, anger, stress, and tension. However, since systematic searching, screening, quality assessment and reporting methods were not adopted, this can be considered a narrative review that provided an overview of yoga as an intervention to improve health related problems in an older adult population.

3.9 Chapter Summary and Next Steps

The results of this chapter established that yoga improved a host of physical function outcomes including strength, balance and flexibility, as well as HRQoL outcomes in an older adult population. As discussed in Chapter 1 (section 1.16), only

a small percentage of older adults engage in yoga. Given that a large proportion of this population did not meet the MS and BC guidelines (section 1.11), it is important to understand the perceptions of yoga particularly in those who have never participated in yoga, to identify barriers and apprehensions. This is explored in the next chapter.

Chapter 4. Consultations with Stakeholders

4.1 Introduction

The need to develop an appealing, appropriate and acceptable yoga programme was identified in the introductory chapters. Consulting with stakeholders has been prescribed by numerous intervention development frameworks (Nutbeam & Bauman, 2014; Wight et al., 2016). Existing studies that have developed a yoga programme for older adults are limited in that consultations with the target population have been minimal (section 1.19.2.2). Rich and detailed data from older adults on perception and barriers to yoga participation has not been used to inform intervention development. Collaborations between various stakeholders (such as researchers, practitioners, target population) are considered important during the process of intervention development as they increase the likelihood of programme effectiveness (Wight et al., 2016). This could stem from:

(i) Communication and collaboration between the different groups (Ahmed & Palermo, 2010) so that there is informed decision making (Morgan, n.d.)

(ii) Enabling the programme to be designed in line with the needs of the target population so as to ensure that it is acceptable (Wight et al., 2016), meaningful and engaging to users (Bailey et al., 2015)

(iii) Increasing the sustainability of programmes (Bailey et al., 2015)

(iv) Ensuring that the intervention is practical (Wight et al., 2016), and increasing the likelihood of successful delivery and implementation (Morgan, n.d.)

In this chapter, findings from consultations with two stakeholder groups are presented: (i) Study 2 conducted with the target population consisting of adults aged 65 years and above to understand their perceptions of yoga, gather other inputs to aid intervention development, and compile strategies to encourage yoga participation among this population (ii) KE event conducted in collaboration with those experienced in working with older adults such as yoga instructors, studio owners, and researchers.

4.2 Study 2: Understanding Perceptions of Yoga in Older Adults

4.2.1 Literature review. Four studies have previously addressed the perceptions of yoga in an older adult population (Humberstone & Cutler-Riddick, 2015; Nayak, Patel, Wood, Dufault, & Guidotti, 2015; Patel, Akkihebbalu, Espinoza, & Chiodo, 2011; Wertman, Wister, & Mitchell, 2016). Nayak et al. (2015) conducted a cross-sectional study with 275 older adult participants from Texas, USA (73% female, 85% Hispanic ethnicity) who were beneficiaries of a community centre. A survey that was previously tested and refined (unpublished study) for use among older adults, was employed to understand the barriers, benefits and cues to participating in a yoga intervention. Results indicated that participants perceived that yoga would have physical, mental and social benefits. Lack of time, class too long, dislike of teacher, perception that yoga will hurt or will worsen health problems, and not aerobic were perceived as barriers to yoga participation. Cues that prompted older adults to engage in yoga included having a physical or mental ailment that could be improved by taking up yoga, advice from friends or family members, and media publicity.

The perceived effects of participating in a yoga intervention were captured in a qualitative study (Patel et al., 2011). Participants took part in a 60-minute beginner Iyengar yoga class (consisting of 45 minutes of stretching, flexibility, balance, and endurance poses, and ending with 15 minutes of relaxation/meditation and abdominal breathing), using props such as chairs, blankets, bolsters, blocks, and belts. Focus group discussions were conducted with 12 older adult female participants from Texas, USA (75% Hispanic ethnicity, 20% non-Hispanic White, and 5% African American) at baseline, 12 weeks and one-year post intervention. At baseline, data were procured on reasons for participation, and expectations from the yoga session. At 12 weeks and one year, participants were asked how they were affected by the yoga sessions and if they would continue yoga. Reasons for participation mentioned were physical reasons such as improving health conditions like arthritis, improving mobility, strength, independence, and reducing medication. Mental reasons like relieving stress and relaxation, and social reasons such as having something to do, a reason for leaving the apartment and being able to share what they

have learnt were also mentioned. The main benefits reported by participants at 12 weeks were reduced fear of falls, better sleep, improved mobility, balance, gait, strength, and reduced pain and pain medication. They also reported feeling very relaxed, and mentioned social benefits such as having more friends and meeting even when there was no class. Participants appreciated the use of props such as belts for stretching and chairs for support. They liked the relaxation aspect and felt it could be practiced at home. At one year follow up, further psychological benefits were reported such as reduced feeling of depression and anxiety, more harmonious relationships and improved confidence. Spiritual themes such as feeling more in touch with oneself, praying more and helping with meditation were also identified.

Wertman et al.(2016) employed a mixed methods approach to explore the differences in pathways to joining yoga (cues to action, social network influences, or a health problem that prompts individuals to seek out yoga), motivations, perceived barriers and perceived health benefits between middle aged and older adults from Vancouver, Canada. Quantitative data were collected from 452 yoga participants (77.9% female) using an online survey questionnaire, of which 274 were middle aged (defined as 40-55 years) and 178 were older adults (defined as 55 and older). Semi-structured, in-depth, face-to-face interviews were conducted with a subset of 10 middle aged and 10 older adult participants (equal number of males and females). With respect to the pathways to taking up yoga, quantitative analysis revealed that older adults were more likely to be influenced by a neighbour suggesting yoga, compared to middle aged participants. They were also more likely to be influenced by health-related events like a medical diagnosis, and less likely to read about yoga in books and journals compared to middle aged adults. Analysis of the motivations to join yoga showed that it was more probable that older adults engaged in yoga to prevent osteoporosis compared to middle aged adults. Older adults were less likely than middle aged adults to start yoga to explore spirituality or to meditate. They were also less likely than middle aged adults to engage in yoga to increase MS or to lose weight. Older adults were less likely than middle-aged adults to view social embarrassment or anxieties as barriers to participating in yoga, and were less likely to view class availability as a barrier. It was found that older adults perceived yoga as

less beneficial to health compared to middle aged adults. In the qualitative analysis, friends and family and the influence of media including TV programmes and posters were reported by older adults as pathways to yoga. Social interaction or integrating yoga into aspects of living to bring meaning to life were cited as motivations to participate. While men were more likely to participate for the physical health benefits, women mentioned meditative and psychological aspects. Three male interviewees expressed that acceptance of the LGBT (lesbian, gay, bisexual, and transgender) community in the yoga classes was a motivating factor. Barriers to participation reported by older adults were the lack of time and financial constraints.

Humberstone and Cutler-Riddick (2015) used an interpretative phenomenological approach to explore the bodily and mental experience of yoga participation among older women with at least five years of yoga experience. The authors attended yoga classes, and the study was based on the authors' experiences of yoga, in-depth interviews with 12 women (two thirds of who were from urban High Wycombe and semi-rural South of England, UK), along with participant observation. Participants provided information on reasons for practicing yoga, and comments regarding the spirit and atmosphere of the class, and qualities of the teachers. Women generally took up yoga as a consequence of illness, concern about reducing physical capabilities, and to manage mental or emotional issues. The authors mentioned that spirituality was not the focus of the yoga classes they attended. Study participants revealed that the classes suited them because the philosophical aspect was limited, and they were more interested in flexibility and relaxation. Authors observed that despite the limited mention of yoga philosophy, the physical practices were based on traditional yoga philosophies focusing on the integration of body, mind and spirit. A finding based on their own experience and interviews with participants was that the focus of the classes was not comparison or competition, but being in the moment, and feeling the body movements synchronised with breathing. The teachers were sensitive to the needs of students and would suggest alternate postures and modifications depending on the physical abilities of students. Teachers created a non-judgemental atmosphere where participants could reflect on their bodies and ageing. Positive images of older women were provided by

the yoga teachers who frequently spoke about older, inspirational, positive healthy and physically capable older women.

The main aspects addressed by the four studies are cues or reasons for joining yoga, perceived benefits, barriers, and experiences of a yoga class including ethos and qualities in an instructor. A synthesis of the four studies is presented in Table 14.

Table 14

Summary of previous studies addressing perceptions of yoga in older adults

Authors	Design	Location	Demographics	Findings			
				Cues/ Reasons for joining	Perceived benefits	Barriers	Comments on yoga session/instructor (likes, dislikes, experiences)
Nayak et al. (2015)	Cross-sectional study	Texas, USA	73% female, 85% Hispanic ethnicity	Yes	Yes	Yes	No
Patel et al. (2011)	Focus group discussions at baseline, 12 weeks and one year post intervention of a yoga intervention	Texas, USA	75% Hispanic ethnicity, 20% non-Hispanic White, and 5% African American	Yes	Yes	No	Yes
Wertman et al., (2016)	Mixed methods-online questionnaire and face to face interviews	Vancouver, Canada	Yoga practitioners, 77.9% female	Yes	Yes	Yes	No
Humberstone and Cutler-Riddick (2015)	Interpretative phenomenological approach	Mostly from Urban High Wycombe and semi-rural South of England, UK	Yoga practitioners, 100% females	Yes	Yes	No	Yes

The studies utilised various designs to understand cues or reasons for participation in yoga, perceived benefits, barriers, and experiences with yoga. The advantage of using a cross-sectional design (Nayak et al., 2015; Wertman et al., 2016) was that a larger sample could be recruited. However, the results may be biased if those who consent to take part are different from those who don't (Sedgwick, 2014). Participants in the study by Nayak et al.(2015) were recruited from a community centre, so it could be hypothesised that they were already motivated to get out of the house and more likely to be active. The data in Wertman's (2016) study were collected through an online questionnaire, and hence the sample would consist of only those with a computer. The perceptions of older adults with no access to a computer were not represented. This is a significant criticism of the study, as the bias could have led to lower representation of the oldest old (85+ years), and this is demonstrated in the fact that those aged 70 years and above only formed 2.2% of the study sample. The qualitative methods used in three of the studies (Humberstone & Cutler-Riddick, 2015; Patel et al., 2011; Wertman et al., 2016) were appropriate to gather rich data on the perception of yoga.

Participants in the studies by Patel et al. (2011) and Nayak et al. (2015) were predominantly Hispanic. As expected, all four studies recruited a higher proportion of women. Patel et al. (2011) and Wertman et al. (2016) included generally healthy adults, and a degree of selection bias in these studies is obvious. Only one study recruited participants from the UK (Humberstone & Cutler-Riddick, 2015). Among the three studies using qualitative methods, all participants were either already participating in a yoga programme or had agreed to take part in a yoga programme (Patel et al., 2011). Although participants would not have experienced yoga during the baseline data collection in the study by Patel et al. (2011), these focus groups addressed reasons for participation, and expectations from the yoga session, and not barriers to participation. No study with a qualitative design has explored the perceptions of yoga in Scottish and European older adults who have never participated in yoga. Understanding the barriers and apprehensions to yoga in older adults with no yoga experience is vital while developing a yoga intervention that is appealing, appropriate and acceptable, and while designing strategies to encourage yoga participation. Comparing feedback from older adults with yoga experience and those who have never done

yoga will help to understand how to address some of these barriers, and pinpoint intervention components and strategies that are viable for this population.

4.2.2 Study 2 published manuscript. The initial section of Study 2 was published in the Annals of Yoga and Physical Therapy journal on 1st November 2017.

Title: Perceptions of Yoga among Older Adults: A Qualitative Approach
Authors: Divya Sivaramakrishnan, Dr. Claire Fitzsimons, Prof. Nanette Mutrie and Dr. Graham Baker

The contents of the manuscript have been integrated into the thesis to provide a seamless flow. The published manuscript is attached as a supplementary file (Appendix 15).

4.2.3 Study 2 aims. This study seeks to understand the perceptions of yoga among males and females over 65 years, from a mixed sample of participants with and without prior yoga experience. The aim of this study is to:

- explore the perceptions of yoga in adults over 65 years
- understand why yoga is a female dominated activity
- provide guidance for yoga instructors
- strategies for promoting yoga in the older adult population
- procure intervention specific inputs pertaining to intervention frequency, duration, nomenclature, class specifics etc.

4.2.4 Study 2 methods

4.2.4.1 Participants. Male and female participants were recruited through convenience sampling, including those with previous yoga experience or currently practicing yoga (yoga participants, YP), and those who had not done yoga in the past five years (non-yoga participants, NYP). The study inclusion criteria were that the participants should be 65 years and above, and should be able to speak and understand English. For the YP group, the number of years of yoga practice was not

a criterion for recruitment. Participants with yoga experience were recruited from yoga classes at a local leisure centre, and a university fitness facility. Participants for the NYP group were recruited through programmes for older adults run by a local leisure centre. The lead author made announcements regarding the study at these venues, and approximately 30 people expressed an interest in participating. Interested participants were given a study information sheet (Appendix 16) describing the study objectives and what participation in the study would entail, and any questions raised were answered. Approximately 37% dropped out due to unavailability on the suggested dates. All participants gave written informed consent (Appendix 17), and ethical approval for the study was obtained from an institutional ethics committee (Approval letter attached as Appendix 18).

4.2.4.2 Instrumentation and data collection. Focus group sessions were initially considered the appropriate method for collecting data, as interaction among participants would yield richer information (Barbour, 2007). The recruitment of non-yoga participants and men proved challenging. Hence, data collection procedures were amended, and a mix of focus groups and interviews were conducted with these participants. The data were collected between November 2016 and March 2017. The sessions were conducted at the venues where the yoga classes were held, and at the location where some leisure centre programme members had their regular meetings.

Similar but separate topic guides were developed by the primary researcher for the YP and NYP groups, and were reviewed by a panel consisting of the authors and 3 external members with diverse experience relating to yoga, physical activity research and health. The guides (Appendix 19 for YP and 20 for NYP) were revised based on suggestions from the panel. The topic guide for the YP group had questions relating to overall experiences with yoga, and the benefits and challenges, whereas the NYP group topic guide enquired about the potential benefits and apprehensions with yoga. Pictures of a yoga class and a two-minute video of yoga stretches were shown during the session to stimulate discussion. All focus groups/interviews were moderated/conducted by the lead author (DS), with a co-moderator present for the focus groups. The moderator and co-moderators were all female. At the time of the

study, the primary researcher was pursuing a PhD. She has a Masters in Sport and Health Sciences, and has undertaken formal training in conducting qualitative research. She is also an experienced yoga teacher.

Before the session commenced, participants were requested to fill out a brief questionnaire to record age, gender and yoga experience. They also completed the short version of the International Physical Activity Questionnaire (IPAQ-SF) (Booth et al., 2003), which captured information on time spent walking and performing vigorous-intensity and moderate intensity activities. Participants were then categorized into low, moderate or high physical activity levels using the scoring protocol for the IPAQ-SF (Appendix 21). All sessions were audio recorded. Additional notes were taken during the sessions, and a brief discussion between moderator and co-moderator ensued after the focus group sessions.

4.2.4.3 **Data analysis.** Thematic analysis (Braun & Clarke, 2006) was used to analyse the transcripts, following the suggested step-by-step process. The first step was familiarisation with the data. The focus group and interview recordings were transcribed verbatim either by the lead author or an external professional transcription company. Transcripts were read through several times. For step two, three researchers (DS, CF, GB) conducted line-by-line coding of one transcript. Initial codes were then generated by the primary researcher for all transcripts, and were transferred to a computer software package (Nvivo 11 for Windows). The third and fourth steps included searching for themes and refining them, and the software was used to manage the codes and thematic structure through this process. For the fifth phase, the essence of each theme was discussed by all authors to define and finalise these. Within some themes, framework analysis (Gale, Heath, Cameron, Rashid, & Redwood, 2013) was used to explore the differences in perceptions between the yoga and non-yoga participants. The software package was used to summarize data into a matrix that allowed for comparing the views of YP and NYP groups across themes and sub-themes.

The notion of rigor in qualitative research is evolving. Researchers have questioned the use of concepts like member checking or participant validation and inter-rater reliability to judge the accuracy and credibility of qualitative analysis (Smith & McGannon, 2017). In this study, rather than researchers independently coding data, and then coming to an agreement over the codes, they acted as critical friends (Smith & McGannon, 2017), where dialogue and discussions guided the coding and analysis process. The COREQ (COnsolidated criteria for REporting Qualitative research) checklist (Appendix 22) was adhered to while reporting on this study (Tong et al., 2007).

4.2.5 Results

4.2.5.1 Participant characteristics. A total of 19 participants attended the sessions (Table 15), and 3 focus groups and 5 interviews were conducted. It was difficult to recruit sufficient men to organize focus group discussions therefore individual interviews were conducted with male participants. The average age of the participants was 74 years (range: 65-84 years). Forty-two percent of the participants reported high physical activity levels, 32% reported moderate levels, and 21% reported low levels. The average duration of the sessions was 55 minutes (standard deviation: 11).

Table 15

Number of study participants by gender, yoga experience and attendance at focus groups or interviews

	Gender				**Total**
	Female		Male		
Yoga experience	Focus groups	Interviews	Focus groups	Interviews	
Yoga participants	9	0	0	2	11
Non-yoga participants	4	1	0	3	8
Total	14		5		19

Themes were identified and categorized under five broad topics: perceptions of yoga, gender, guidance for instructors, strategies for promoting yoga, and intervention specific inputs.

4.2.5.2 Perceptions of yoga

4.2.5.2.1 General perceptions about yoga. Participants from both groups felt that yoga was an activity that was suitable for older people for a number of reasons. It was described as a good, all-round workout for an older person. As described in the following quote (female, YP), participants felt yoga is something that you could continue to do at their stage of life-

..all of us probably did hockey or netball or something else. Obviously, at our age we don't rush around playing netball or tennis as much. And yoga is something that you can do.

They felt that yoga was inclusive, not too strenuous, and unlike many other activities, did not need much preparation.

Participants with yoga experience perceived it as a body and mind activity that brought breathing and movement together. They were aware of the different types of yoga, and its physical, mental, relaxation and spiritual dimensions. They had a very positive view of yoga, and expressed that they enjoyed and loved doing yoga. Another perception that came through strongly was the non-competitive aspect of yoga. The YP group described yoga as a journey where you don't force yourself, and do it to your own ability. One participant (male, YP) reflected-

"The great thing about yoga is that each person goes to what the teacher calls your edge. You should go to your edge and not beyond it. Different people have different edges for different postures."

The yoga participants also felt that while you may feel embarrassed if you fall in other classes, this does not upset you in a yoga class.

Some participants in the YP group described yoga as a different form of exercise, in that it is not a regimented activity, and works on the body differently from other exercises. One male participant felt that after a yoga class you feel you've exercised to the same degree as marching, and have exercised all your muscles.

Among the NYP group, many participants said that they did not know a lot about yoga, and were unsure about the different styles. A few were aware of yoga as

it had been advertised in libraries and churches. One participant (male, NYP) was knowledgeable about the concept of yoga-
"So for me yoga has been how you combine physical positions with a beneficial way of meditating and thinking about whatever, the deeper matters of life."

Both groups viewed yoga as an activity that's not too vigorous, and slower and easier compared to other activities. However, some non-yoga participants perceived yoga as something one does on the floor, to do with sitting and not associated with movement.

4.2.5.2.2 Benefits of yoga. Participants who had done yoga felt that it was beneficial on many levels as evidenced by this quote (female, YP)-
"I think it brings three benefits to me…it's the physical fitness postures which stretch you and keep you flexible, maybe not as flexible as we used to be but at least it stops you getting worse, and secondly, it's a sort of emotional balance and harmony and whatever, relaxation is great, and the third part…that's the meditation and the concentration on the inner self which is interesting."
The yoga participants described the benefits of yoga in detail:

(i) Physical benefits. The YP group felt that yoga helped keep fit, and improved flexibility, suppleness, strength and balance. They also felt that yoga helped with other sports and activities like badminton. Good posture was seen as a major benefit. Participants also expressed that yoga helped with joint and back problems, to ease pain, and aided recovery from any problems one might have. One participant felt that yoga helped her prepare, and recover from hip replacement surgery, and felt it gave her the confidence to do things post-surgery.

(ii) Mental benefits. Yoga was thought of as calming and peaceful by yoga participants. They felt that it relaxed them, and enabled them to sleep better. Yoga was found to be good for the mind, stimulated thought, and taught concentration. These older adults felt that yoga improved their self-efficacy and participants felt that

they were learning, getting better with some postures, and were surprised when they found they could do some of the yoga poses.

(iii) Benefits of breathing. Many yoga participants liked the meditative and spiritual aspects of yoga, as well as the breathing. They found that breathing was invigorating and relaxing. It had a calming effect and helped get rid of worries. It helped get a grip of oneself, and hence could be used during a visit to the dentist, or while getting an injection.

The NYP group named some but not all of the above benefits of yoga. They felt that yoga was good for the body and mind, and could help with sleep difficulties, and sore backs and knees. Improved strength, balance, coordination, flexibility and toning were also mentioned as perceived benefits by the NYP group.

4.2.5.2.3 ***Apprehensions.*** The non-yoga participants expressed many apprehensions with regard to taking up yoga. Male participants felt that yoga was not aerobic enough, circulation and muscles would not be challenged and that no sweating would occur. Yoga, they felt was about a higher level of suppleness not really necessary for everyday life.

The non-yoga group also anticipated that they would struggle with yoga, they would find it difficult and demanding, and wouldn't be able to do many of the exercises. Holding a posture, which might lead to cramps, and balance exercises were regarded as particularly challenging. Some perceived yoga as contortions and difficult positions as expressed by a female, non-yoga participant-

I think if the word yoga was in it, I wouldn't be interested because you have a different perception of yoga…because all I've ever seen about yoga or known about yoga is difficult positions on the floor.

Some non-yoga participants felt that they would be embarrassed in class if they couldn't do the things asked of them. They were also worried about getting down and up from the floor during a class.

Lack of information about yoga was a huge barrier to participation. One non-yoga participant felt that people don't intuitively know what to expect with yoga, in contrast with swimming or walking. Moreover, it was not clear what types of yoga would be suitable for older people.

Participants from both groups indicated that there might be a stigma around yoga. Yoga could have religious connotations, projecting an image of someone sitting cross-legged. Phrases like "airy-fairyness", "for the flower power people" or "for the third age" were used to describe the impression some people may have of yoga. Non-yoga participants viewed yoga as a background to spiritual activity, and shied away as they thought it would have considerable meditation and spiritual content.

4.2.5.2.4 Social aspect. The yoga participants stressed the value and importance of social interaction. They felt that the yoga class was friendly and social, and they immensely enjoyed the discussions over coffee after classes. They also reported that some people who gave up the class still joined for coffee and lunches. The social bonding helped them feel included and supported. The participants in the two focus group sessions knew each other very well as they had been doing yoga together for a long time. The friendship and affection between them was evident. This quote (female, YP) shows that the effects and benefits of yoga go beyond the studio to make a deep and lasting impact-

All of us have had things that have happened, life-changing things, like ten years ago I had my breast cancer and I was off yoga and all the other classes for a year. And the yoga teacher sent me some sheets, printouts of exercises, mostly breathing exercises, and that sort of thing, and that was lovely because I did them and I felt

still included in the group, and others have perhaps lost husbands or illnesses and things, and we all have supported each other through that. Phone calls and letters…

However, the non-yoga participants thought that the social aspect may be missing with yoga. Unlike walking where you interact during the activity, yoga was perceived as an individual activity like swimming.

4.2.5.3 Gender. The yoga participants observed a preponderance of women in yoga classes. Reasons for this gender bias were discussed by all participants, and an emerging critical factor was that it may be considered a feminine activity. Both groups expressed the view that older men still had a macho man attitude and regarded yoga as a "cissy" activity. Men may also be more self-conscious and don't want to be seen as unable to do something. Some men suggested that yoga was more suitable for women as they have a degree of suppleness that men don't have. One male yoga participant disagreed with this view. While some men found it uncomfortable to attend classes dominated by women, the two male yoga participants did not seem bothered by this. Although one of them admitted that before he started yoga, he had a perception that it was something that women did.

Another idea discussed was that the gender bias was not unique to yoga, but was prevalent across all exercise and activity classes. One reason offered was that men did not like to join groups and preferred individual activities, while women were more social. Finally, the difficulty of getting men to pay attention to long-term health issues was discussed.

Participants observed that society's view of yoga as a feminine activity was changing, with football and rugby clubs introducing yoga, and young male students joining yoga classes. They offered some suggestions that would encourage men to take up yoga: promoting and delivering yoga through gyms, rugby, football and swimming clubs, and having role models could make yoga more appealing to men. Conducting male only classes and having a male instructor was advocated by some, and dismissed by others. One male non-yoga participant suggested that men need a

soft entry to yoga, so that they enjoyed the activity, built a social circle and felt the benefits of the social aspect of yoga. Finally, targeting younger men was suggested as older men may be too set in their ways, and it may be difficult to persuade them to join.

4.2.5.4 Guidance for instructors. Participants highlighted several qualities they would like in an instructor. They also offered suggestions on teaching methods that would facilitate the effective delivery of a yoga class.

The communication style adopted by instructors during a yoga class emerged as a significant theme. It was extremely important to participants that the teacher was audible, and they expressed frustration when the teacher spoke quietly. They wanted instructors to give clear and precise instructions, and provide explicit directions for each body part. They felt it was important for instructors to demonstrate as they found that understanding movements on different sides of the body was confusing if no visual demonstration was provided. They also found it difficult to watch the instructor and do the postures at the same time, and hence felt that the instructor should first demonstrate and then they would follow.

In line with yoga being perceived as non-competitive, participants felt that the instructor should create a non-threating and comfortable environment, where a participant is not forced to do anything. This is evident in the following excerpt from a focus group session (females, NYP)-

Participant 1: You have to be reminded that, that's okay. If that's as much as you can do, that's okay.

Participant 2: To take the lower option.

Participant 1: And you don't feel embarrassed and you don't feel, well, I can't keep up with them so I'm not going to go anymore.

Participant 3: Yes, you've got to do it at your own pace.

Participants stressed that an instructor should be sympathetic, patient, approachable and encouraging. They appreciated it when instructors were caring and took an interest in each individual, asking about injuries and health problems. Hence being aware of the class, and their abilities was important to participants, who were put off if they were taxed beyond their capabilities. Participants emphasized the importance of offering alternative exercises while working with older people, using props like chairs or providing easier options. They valued training and experience in a teacher.

A male yoga participant said that he hurt himself in yoga on one occasion, which may have been caused by the instructor giving him a push while in a yoga pose. Since instructors may not be aware of the physical condition of every student, it may be prudent for them to abstain from manually correcting the postures, and instead provide verbal feedback.

4.2.5.5 Strategies for promoting yoga. Participants from both groups suggested some strategies to overcome apprehensions and promote participation in yoga.

Providing more information around yoga and publicising the benefits would assuage some of the fears of non-yoga participants, who felt they may be more motivated to join if they understood the benefits. Non-yoga participants were keen on yoga tasters and introductory sessions, so that they could try and see if it was for them. Introducing a bit of yoga in other exercise classes was another strategy suggested. It was recognized that people who do yoga had a big role to play in encouraging partners and friends to join. Although this has not always been successful, many in the yoga group were themselves brought in by people they knew, and hence experienced a degree of comfort while joining.

Participants felt that yoga could be promoted more by healthcare professionals and physiotherapists to address medical issues. The following quote (female, YP) elaborates the premise and reason behind this suggestion.

I also think medically they could promote it some more. Because I have arthritis, basal arthritis. Now, they wanted to immediately give me injections, and with an operation in two years' time. And I said no, I want you to give me a series of exercises. Which they have done. And I went back last week, and she said the injections are really working. I said I haven't had the injections. She never suggested exercises. And I think medically, they could suggest. That's the first, try it, and if it doesn't work then move on to the next.

Finally, promoting yoga during retirement courses using videos and demonstrations was suggested.

The four themes mentioned above have been summarised in Figure 18. Examples of quotes for each theme and subtheme have been compiled as a table and attached a supplementary file (Appendix 23).

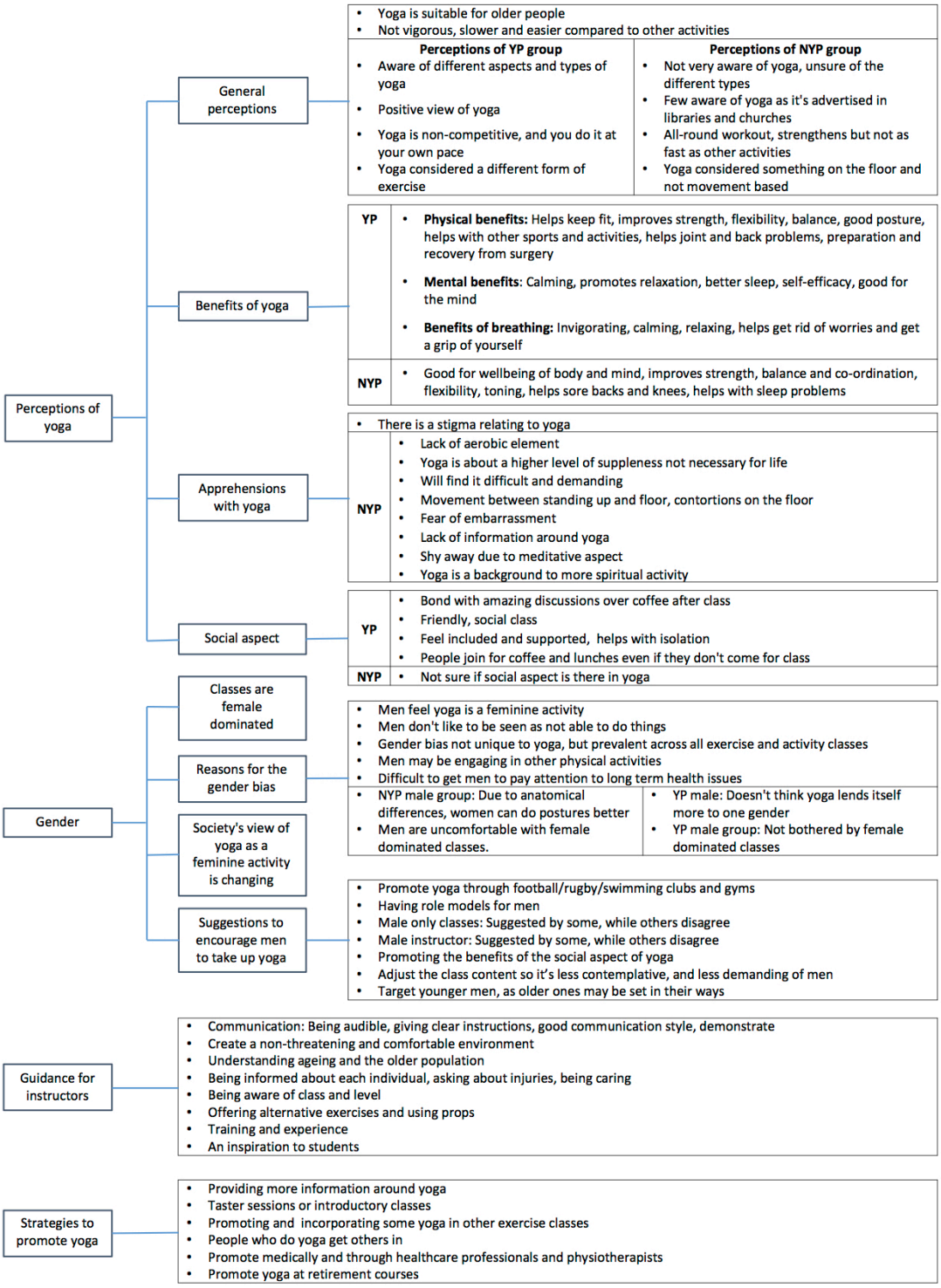


Figure 18. Perceptions of yoga in older adults- themes and sub-themes
YP: Yoga participant, NYP: Non-yoga participant. Themes pertain to all participants unless specified.

4.2.5.5 Intervention specific findings

4.2.5.5.1 Duration of session. Comments on the preferred duration of a yoga session fell into three categories:

(i) Less than one hour. A duration of less than one hour was only suggested by the NYP group. They preferred 30-50 minutes, as they felt they might get tired in a longer class. They also had the impression that you exert yourself too much as you get older. Another suggestion was to start with a shorter duration and then build up.

(ii) More than one hour. This was preferred only by those in the YP group. They felt that an hour and quarter or an hour and half would be ideal, as they liked having about 10 minutes of relaxation time at the end of a class. Some in the YP group felt that an hour may be too short, and would need to be extended to ensure that the class is not too rushed.

(iii) One hour. Some participants from both the YP and NYP groups were comfortable with one hour as the duration of the session. The NYP group felt that one hour including the relaxation aspect would be fine. However, they preferred to be active for about 50 minutes during the course of the hour, as can be seen from this excerpt from two male NYP participants-

Responder (R)1: I think an hour maximum as far as I'm concerned. And if we're active for say fifty minutes of that, that's probably about right for me at this stage. (Male, NYP, 76 years)

R2: I think that's about right too. That's about right. (Male, NYP, 77 years)

4.2.5.5.2 Frequency of sessions. Once or twice a week was the frequency of yoga sessions preferred by both YP and NYP groups. The main reason for preferring once a week was that participants from both groups felt they were busy despite being retired. They were also attending other classes and participating in other activities like walking and swimming. Some participants preferred two classes a week, as they were aware of an increase in stiffness after a week's break, and did not feel ready for the following class.

One probably needs at least two days a week. Otherwise, Monday to Monday is rather a long stretch. You're oh, I'm a bit stiff or whatever, I'm not ready for this class. (Male, NYP, 76 years)

Participants from both groups felt that it was good to split up the week with a class scheduled in the middle. One participant from the NYP group said she would attend everyday if she found that yoga really was beneficial.

4.2.5.5.3 Nomenclature. Several views were expressed on whether a yoga programme should be called "yoga", or if the word was unfamiliar and unattractive to older adults.

(i) The name yoga is appropriate. This view was expressed mainly by the YP group and one member of the NYP group. Using yoga as the name was suggested as it informs you of what it is.

I think it just says what it is. (Female, YP, 82 years)

The YP participants felt that yoga was an established discipline, and it was important to continue to use this name, so that people were aware that it was not some new idea that had been recently concocted.

Your using the word yoga, would mean that they would have a known medium that they'd be starting to use. It's not just some new idea, that some local instructor has dreamt up to get you bouncing about. (Male, YP, 67 years)

Participants from both YP and NYP groups preferred "yoga" to "mindfulness". They felt yoga sounded more practical than mindfulness, and there was some confusion about what mindfulness really was. They also felt that the word yoga reflected both physical and psychological benefits, whereas mindfulness was perceived as being associated with purely psychological benefits.

(ii) Change the name. Changing the name from yoga was mostly advocated by the NYP group. It was suggested that yoga should be re-labelled to encourage more men to join. Using words like core training or strength building was suggested so that it would be appealing to men. It was also felt that yoga was not a modern name. The NYP group felt that the term yoga conjured up "old fashioned" images of contortions and spiritual activities.

Because sometimes yoga sounds like something for the third age or whatever they call it. (Male, NYP, 77 years)

One participant in the YP group thought back to the time when she took up yoga and remembered that she had some apprehensions with the name yoga, and was worried that there would be a lot of spiritual content. The NYP group felt that yoga came with this baggage because of how it has developed and progressed, and hence needed to be rebranded. Another criticism of using the name "yoga" was that it did not describe the activity. One male participant from the NYP group felt that names like spinning, walking or swimming actually describe the activity, but with yoga one gets no clue about what to expect. He recommended using a name that explained what the activity did.

..a spinning class, I mean, in your mind it thinks, well something's revolving. Something's turning. That's right. Either you're spinning or you're on a bicycle spinning or you're doing something. Yoga doesn't conjure up anything really to me…
… Cause they use descriptive words. I know maybe Pilates is not very descriptive perhaps, but spinning is and other…there's other words that maybe go with it that describe what the activity is. (Male, NYP, 67 years)

Moreover, NYP participants felt that yoga had benefits like improved balance and posture that people were not aware of, and wondered if the name could reflect these benefits. They supposed that a programme named "Posture and balance class" would not be relegated to just religious or "flower power" people. However, NYP also cautioned against changing the name to something that gave the wrong impression. They felt that while you shouldn't change the essence of what yoga really was, the name should be appealing enough to prompt people to try it.

(iii) Changing the name will not encourage participation. A contrasting view that the YP group had was that even if the session was given a more neutral name, those not interested in attending classes would still not be persuaded to join.

...I don't think calling it balancing and control would make any difference. (Male, YP, 80 years)

This applied more to men, and ties back to the identified barrier (Study 2 Part 1), that men are reluctant to attend activity classes-
My husband does at least an hour's exercise every morning in life, because of a sore back. And it's a preventive etc. He would no more come to a class, whatever it was called. But that's him. (Female, YP, 72 years)

(iv) Add to the name. A suggestion mainly from the NYP group was to have an addendum to the name. They suggested retaining the name "yoga", and then elaborating on it. The tagline or addendum to the name could aim to explain what yoga was, and describe for whom it was suitable. It could also reflect benefits of yoga like balance, stretching, and strength. Some suggestions included "mature movers" and "over 60s", with yoga for beginners being preferred to yoga for older people.

4.2.5.5.4 Class specifics

(i) Extreme and complicated movement. Participants in the NYP group expressed that they disliked extreme movement, as can be seen from the following conversation between females in the NYP group-
R1: ...but I don't like moving from extreme..you know from up to down. If I'm on the floor, I want to do floor work. If I'm standing, I want to do standing work, because getting up and down is… (Female, NYP, 68 years)
R2: Yes, at our age it's not quite as easy as it was. (Female, NYP, 68 years)

Participants stated that they might feel dizzy if they got up too quickly, and recommended that movement between postures should be gentle. They also felt that complicated twists and turns should be avoided.

(ii) Pace. Most participants preferred a slow and gentle pace, that was not too vigorous. It was felt that a gentle pace would be more suitable for people who were

new to yoga. Only one NYP preferred a faster pace, and expressed that she found it difficult to slow down and relax.

(iii) Monotony vs introducing new things. Participants from both groups felt that classes should not get too repetitive or monotonous and should introduce new things. This was thought to be important as different muscles would be used while doing new exercises. Participants also appreciated being challenged and pushed. They needed to feel that they were progressing-

..and they've (gyms) got, like....a plan that you build to get better at doing the thing. So you would need to do something like that I think. (Male, NYP)

Participants felt that having a measurable goal would be good. At the same time, the importance of a balance between being pushed and being allowed to adopt your own pace was emphasised by one participant. This is evident in her response when asked about being motivated by a challenge or a goal-

R: Yes, to a certain extent..but I wouldn't want pressure put on me.
Interviewer (I): So I think I'm hearing that your own pace is something that's important to you, to be able to take it at your own pace and level..
R: Yes, I don't want to be taken by the hand, but I don't want pressure.
(Female, NYP, 65 years)

Participants also felt that not too many new exercises should be introduced, and they should be introduced gradually. Otherwise, it would get complicated and confusing, and could put them off.

(iv) Class structure. A class structure that NYP participants were comfortable with was starting with a warm up, followed by the main section/period of activity including stretches, and ending with a cool down and relaxation. A small amount/short period of spiritual content, but not too much, was preferred by both groups. A YP expressed that while he doesn't object to the spiritual dimension in class, it is not an important reason for attending the class. One female NYP felt that she may be ok with meditation and relaxation but not with religious content:

R: I remember my husband going to a yoga class in Morningside all these years ago, but he said something about, oh, she was talking about religion more than the actual…I think he wanted more than that.

I: Yes, a good point. Do you think that would bother you if it had more of a spiritual or…?

R: Well, a bit of meditation and quiet time and that kind of thing.

I: You're okay with that.

R: I would be okay with that but no kind of religious…

(Female, NYP, 76 years)

The YP group felt that the relaxation aspect such as the corpse pose was essential, and they enjoyed it. Some participants preferred breathing at the beginning, while others felt that the class should end with breathing and relaxation.

(v) Props. Members of the YP group said that in their current class, they were encouraged to use props like a chair or the wall if they were unable to do a particular posture. They appreciated being offered an alternative pose using props. However, one NYP said that chair exercises wouldn't excite her as she felt that they were for older people. She presented an opposing view at another point during the interview, saying that she would enjoy working with props and equipment. This was in reference to weights used during an activity class she attends. It would seem that she associated chair exercises with an older age group, but was keen to use props like weights.

4.2.5.5.5 Number of participants. Participants from both groups preferred a smaller class. Around 15 to 20 people in a class was mentioned as ideal. Bigger class sizes were not preferred as the participants felt that crowded classes ruined the ambiance, and contradicted the calmness and peace associated with yoga. Also, the teacher would not have the time to pay attention to everyone in the class. Those from the NYP group were apprehensive about very small class sizes, as it would make them the focus of the teacher's attention. Finally, some participants were indifferent to the size as long as there was enough space for a mat and to stretch out their arms. It was also important that one was able to see and hear the teacher.

One NYP male participant expressed a preference for one-on-one sessions. The participant had damaged one of his discs and was anxious about injuries. Due to this, he stayed away from activities that involved a lot of stretching and bending. He felt that he would need to start with individualised classes to understand what yoga was about, and what he could and could not do.

4.2.5.5.6 Attending classes with people of the same level. NYPs mentioned that they would like to attend classes where everybody was starting at the same level. By "level", they were not referring to fitness levels or capacity, but to the level of yoga proficiency. They expressed a preference for a beginner's class, where everyone was new to yoga. One female NYP stressed that she did not mind people of different age groups joining the class as long as they were at the same level. One group of YPs attended a yoga programme that used to be exclusively for older adults but now was an open class. While they did not object to attending an open class, they would have preferred to have the choice of either attending a communal class or a class exclusively for older adults.

4.2.5.5.7 Home-based vs class-based. Many participants from both YP and NYP groups felt that they might not do the home-based exercises, and listed the reasons why they did not favour practicing the exercises at home:

(i) Time, space and distractions. Finding the time to do the exercises was perceived as a challenge for older adults. While a few felt that they should have the time given that they were retired and did not have the stress of a job, many felt that they had too many things to tend to and were prone to postponing. Moreover, they felt that there were too many distractions getting in the way of home practice. While most mentioned that creating space for home-practice was not an issue, some mentioned that this could be difficult as they might be restricted by furniture.

(ii) Teacher. An important reason why older adults preferred class-based exercises was the presence of a teacher. Doing the exercises incorrectly was a great fear, as it could result in injury. Getting proper instructions on doing the exercises

correctly from a teacher was cited as a distinct advantage of attending a class. Only one male YP felt that the risk of damage while doing exercises at home was very low.

(iii) Social aspect. Participants appreciated the social aspect of a class-based session, and felt they would be isolated doing the exercises at home. They motivated each other in a class, and would find it difficult to do the exercises alone. They also enjoyed going for coffee after classes. Since the social aspect would be missing, they felt that home-based practice was not a long-term option.

(iv) Motivation. Participants from both groups felt that they might have the good intention of exercising at home, but the initial enthusiasm would wear off. They felt that a great deal of self-disciple was required for home-practice, and they would need to regiment themselves with a strict schedule. Many mentioned that they lacked the requisite self-discipline for home-practice, and needed the structure of a class-based session. Some felt that if home-based practice was presented as a challenge, with some reward at the end, they might be motivated to do it. Some participants also mentioned that reaping the benefits of yoga, if they found that it was working and helping them, might motivate them to practice at home.

Few participants (YP) said that they would practice yoga at home. Some mentioned that they occasionally did a few exercises to loosen up. This included stretching and breathing, but not in a structured way. Some participants expressed that they might take up home-exercises if it was recommended for a specific therapeutic reason.

While participants felt they may not be able to do a full one-hour session, they seemed amenable to doing shorter 5 – 10 minute sessions at home. They were also more comfortable doing exercises that they had already done in class with the teacher. It was felt that home-based practice might be useful for beginners, or for those who were unable to attend a class for any reason.

4.2.5.5.8 Handout vs videos. Some from the YP group felt that they had been doing the exercises for a long time, and did not need any additional material to support home-based practice. Others discussed whether they preferred handouts or videos to assist with home-based practice.

(i) Pro handout. The YP group mentioned that handouts could be useful, serving as a reminder and providing structure for home practice. Participants from both groups voiced that additional material delivered via videos would not be useful. They said that it would be difficult for them to access a video as they did not own a computer or an ipad, neither did they access the internet regularly, and therefore would miss the video if it was sent via email. They also did not have video facility in the space where they would do their exercises. They suggested keeping the handout simple with good pictures. They also complained that handouts and books only carried pictures of young and supple girls in complicated positions.

(ii) Pro video. Some participants felt that moving pictures would be easier to follow, and more motivating than handouts. They also mentioned being comfortable using the internet, and said that they would be able to access videos.

4.3 Knowledge Exchange Event

A KE event was held in October 2017 at the University of Edinburgh. This was an opportunity for people interested in delivering yoga for an older age group to come together and discuss common issues, share experiences and propose solutions to improve engagement and delivery of yoga classes for this population.

4.3.1 KE event recruitment and participants. A poster (Appendix 24) was created for the event, and hard and electronic (email attachment) copies were sent out to yoga studios and yoga teachers. Personal contacts such as researchers in the field of yoga and yoga teachers were sent invites. Those contacted were requested to pass on information regarding the event, and word of mouth was used to reach anyone potentially interested in the topic. Twenty-five participants from across Scotland attended the event including yoga teachers, studio owners, programme coordinators

(for example from community leisure centres), and researchers. A majority (60%) of the participants were yoga teachers.

4.3.2 KE event agenda and format. A PhD colleague (Mary Alison) and my supervisor (Dr. Claire Fitzsimons) helped facilitate the event. A professional illustrator, Josie Ford captured the event through live illustration.

The agenda for the four-hour event included sharing of findings from the systematic review (Study 1) and older adults' perceptions of yoga (Study 2), intermixed with activities. The activities were conducted during the event with the aim of discussing the research evidence presented, as well as procuring suggestions and strategies on developing and delivering an appealing, appropriate and acceptable yoga programme, and encouraging more older adults to take up yoga. The activities have been described below:

Activity 1: Discussion in groups on key findings from the qualitative study (Study 2). This activity was designed in a carousel format with four flip charts, each assigned one of four discussion topics-

1. Yoga participants' positive view versus apprehensions of those with no yoga experience
2. Reasons why yoga is a female dominated activity
3. Guidance for instructors
4. Strategies to promote yoga in older adults

Participants were divided into four groups, each spending 5 minutes on a topic to share thoughts, experiences and suggestions before moving to the next.

Activity 2: Participants were asked to think of some do's and don'ts to consider while designing a yoga programme for older adults. They worked in pairs for this activity and displayed their suggestions on post-it notes. A discussion on some of the suggestions ensued.

Activity 3: A group discussion on two questions-
Question 1: Would you be using/ implementing anything from today's workshop?
Question 2: Which aspects of yoga for older adults do you think we need more research on?

4.3.3 Data analysis. Responses to Activity 1 and Activity 2 were first transcribed from the flipcharts and post-it notes. They were then analysed and grouped into three categories: inputs on the yoga programme, guidance for instructors, and yoga promotion strategies. Audio transcripts were not available for the entire event, but some portions were retrieved. The available audio files were used to procure quotes to support findings.

4.3.4 Results

4.3.4.1 Inputs on the yoga programme. Participants at the KE event agreed with the findings from Study 2 that a yoga class for older adults should adopt a slow and gentle pace, and avoid continuous movement between standing, and getting down on the floor. KE participants suggested clustering of standing, and postures on the floor separately. Having options for seated exercise was also recommended.

With respect to class content details, longer warm-ups were advocated. KE participants recommended holding postures, and avoiding inversions. It was felt that having a way to mark progress in a student's practice would make yoga more appealing to men. Making students aware of changes in their body due to yoga would keep them more engaged. It was considered important to have familiar postures and also introduce something new during yoga sessions. Incorporating breathing and relaxation including the corpse pose was considered vital.

4.3.4.2 Guidance for instructors

(i) Understand the physiology of ageing and ask about injuries and health conditions. KE participants felt that it was important to understand the physiology of ageing. Asking if yoga participants had any health issues or impairments such as hearing or sight, and offering subtle or discrete options for people to disclose and

discuss issues was suggested. Subtle options could include provisions to get in touch with the instructor in advance of the programme or session, meeting before or after classes for a private conversation, or opportunities to let instructors know during the class. Since benefits from yoga may not be realised immediately, setting expectations with yoga participants was recommended-

if somebody comes up with a specific problem at the start of the class, we need to let them know it's a long-term thing. Yoga isn't something that'll help in a couple of weeks. (KE event participant)

KE participants recommended that the instructor should ask people with impairments to provide insights on what would be helpful-

..you have to use the insights of the older people around you to help you, so find somebody who's got a hearing difficulty in class and ask them what they need..and that'll give you some tips that will help other people with hearing difficulties.. (KE event participant)

(ii) Creating a non-threatening class environment and reducing feelings of embarrassment. To create a non-threatening class environment and reduce feelings of embarrassment, it was recommended that older adults at a yoga class should not be forced to perform postures, and should be given the option to avoid poses that they were not comfortable with. It was also advised that classes should not be too competitive or goal oriented, and individual encouragement and feedback should be provided without spotlighting people. KE participants felt that yoga teachers should not make assumptions about participant's prior knowledge or physical ability.

(iii) Posture modifications. Providing posture modifications and alternative exercises and using props was considered essential. It was important that instructors have knowledge about the posture adaptations and contraindications for common health conditions in an older adult population. Participants at the KE event warned yoga teachers against assuming that people want to be adjusted into more advanced postures.

(iv) Challenge and pain. A distinction was made between challenge and pain. While it was emphasised that doing yoga should not be painful, it was also felt that an ethos of optimising the potential of each participant should be adopted. Yoga can be described as a journey of self-discovery. The philosophy of understanding yourself and finding the best version of yourself permeates through all aspects of yoga. While performing postures, this would mean taking yourself to your own limit, where you are not forcing yourself but giving all to the posture.

(v) Demonstration and communication. Demonstrating was considered important, and asking an older person to demonstrate in class may be helpful. However, instructors were advised not to demonstrate advanced postures to show off. Creating good rapport with participants was considered important. Suggested communication strategies included speaking clearly, providing clear and precise instructions and repeating instructions if necessary, avoiding judgmental, age-related, negative language, and avoiding jargon. The language used should be understood by all, and hence the comfort level of the class should be ascertained before using Eastern languages such as Sanskrit (classical Indian language). Creating a connection between yoga and daily life was suggested so that students could understand the functional benefits of yoga. For example, postures that would help with everyday activities like tying shoe laces, or postures that would help with playing golf could be highlighted.

(vi) Training and experience. Studio owners acknowledged the importance of training, and stressed on the recruitment of experienced instructors.

4.3.4.3 **Other class details.** KE event participants recognised the importance of the social aspect of a yoga class, and suggested offering post class social options.

..having a bigger social aspect to it, so they can find somewhere for a catch up afterwards..because it could be the only time they get to meet someone else.. (KE event participant)

With respect to class environment, it was considered essential that the room was comfortable and welcoming, had the right temperature and was draught free, was clean and had good lighting. A quiet location was recommended for participants who may have hearing issues. Props like chairs should be made available.

It was felt that it would be difficult for a teacher to manage a class size of more than 10-12 people. Having additional teachers to assist during a yoga session was suggested. Having shorter classes was another suggestion. Participants felt that different levels of classes should be offered instead of lumping all students together. Moreover, "stage not age" was considered important, as older adults could have different fitness levels.

4.3.4.4 Yoga promotion strategies. Older adults (from Study 2) expressed confusion about what kind of yoga to practice. Hence it was felt that clarity on what the class involved, who it was for, and even explicitly mentioning that there won't be contortions was important while advertising a yoga programme-

When you're advertising a class for this population, being really clear what the class is going to involve and who it's targeting, even saying it's not about wrapping your legs around your head. (KE event participant)

The participants at the KE event felt that it was important to promote the health benefits of yoga such as stress reduction. It was felt that mentioning benefits like helping with injuries and improvement in sporting ability would attract men. In addition to the evidence on benefits of yoga presented from Study 1 and Study 2, KE participants postulated that benefits such as improvements in brain function should be advocated-

..publicising the extensive health benefits of exercise, and also yoga for its capacity to stimulate brain growth and increase neural connections..that needs to be more widely publicised.. (KE event participant)

The following strategies for promoting yoga compiled in Study 2 were re-emphasised by participants during the KE event-

(i) Incorporating some yoga in other exercise classes and activities.

(ii) Promoting yoga through pre-retirement courses and charities.

(iii) Promoting yoga through healthcare professionals. This would mean working with healthcare professionals to increase awareness of yoga, so that they recommend it to patients who may benefit from it.

(iv) Promoting yoga among men by having positive and realistic role models, and attaching yoga to a sports team or sports personality was recommended.

Yoga is seen very often as a middle class, yummy mummy, because of the images that we see..so unless we can change that, have some guys with their gut hanging over, a bit like me, old, doing stuff, you know…positive role models. (KE event participant)

Other suggestions included the promotion of yoga by the health department and in the UK National Health Service (NHS) website, showing informative videos and conducting info-demonstrations. Participants at the event felt that adopting a patronising tone and using jargon while marketing yoga to older adults should be avoided. Using the right picture was considered important and showing pictures of real people was suggested. They also felt that handouts could be used to promote home-based practice.

These inputs and other discussions were captured by the live illustrator during the event and the final output is presented in Figure 19. A report (Appendix 25) was produced after the event and circulated to all attendees to serve as a reminder of the evidence presented and the essence of the discussions.

Figure 19. Live illustration of the knowledge exchange event

4.4 Chapter Discussion

4.4.1 Summary of main findings. This chapter reports on consultations with older adults as well as those with experience in delivering and evaluating yoga programmes for older adults such as yoga instructors, studio owners, programme coordinators, and academic researchers. An important finding was that the older adults with yoga experience enjoyed and valued yoga. Yoga was viewed as an activity that was slower, not vigorous and suitable for older adults by the YP and NYP groups. Consolidation of results from Study 2 and the KE event revealed some prominent themes which would influence the development of a yoga programme for older adults. These included apprehensions with yoga, class content preferences, other class details (frequency, duration, number of participants, age or proficiency/level of participants in a yoga class), social interaction, guidance for instructors, and strategies to promote yoga in an older adult population. A key finding from this chapter is the identification of barriers or apprehensions with respect to yoga participation among those with no yoga experience. The main apprehensions have been summarised in Table 16. The KE participants provided suggestions to address some of these barriers (Table 11). For example, providing options for seated exercise and adopting a slow pace has been suggested to ensure that the programme will be less demanding for older adults.

Table 16

Apprehensions/barriers to yoga participation identified in study 2 and suggestions from KE participants to address them

Apprehensions identified in Study 2 through consultations with older adults	**Suggestions from KE event participants to address apprehensions**
1. Will find yoga difficult and demanding	- Provide options for seated exercise - Adopt a slow and gentle pace
2. Movement between standing up and getting down on the floor	- Avoid continuous movement between standing, and getting down on the floor - Clustering of standing postures and those on the floor separately
3. Fear of embarrassment	Create a non-threatening class environment and reduce feelings of embarrassment: - Ensure participants are not forced to perform postures and given the option to avoid postures - Classes should not be too competitive or goal oriented, and individual encouragement and feedback should be provided - Do not make assumptions about participant's prior knowledge or physical ability
4. Lack of information on yoga	- Publicise benefits of yoga including brain function - Promote yoga through pre-retirement courses and charities - Promote yoga through healthcare professionals - While advertising yoga programmes, provide information on who it is for - Promote yoga using the National Health Service (NHS) yoga web page - Use informative videos and conduct info-demonstrations
5. Lack of aerobic element	
6. Yoga is mostly about flexibility	
7. Shy away from spiritual and meditative elements	

Some elements identified in Study 2 were supported, supplemented or addressed by KE participants. Summaries of elements identified through discussions and interviews with older adult (Study 2), and those identified from the KE event, and the intersection of elements mentioned in both are presented as figures below (Figures 20-24). These include summaries of class content (Figure 20), other class details (Figure 21), social aspect (Figure 22), guidance for instructors (Figure 23) and yoga promotion strategies (Figure 24).

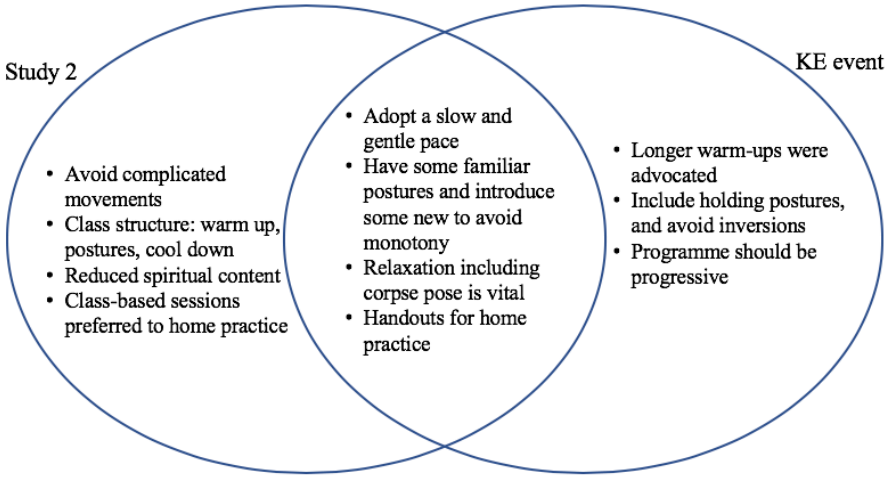


Figure 20. Class content elements identified from Study 2 and the KE event

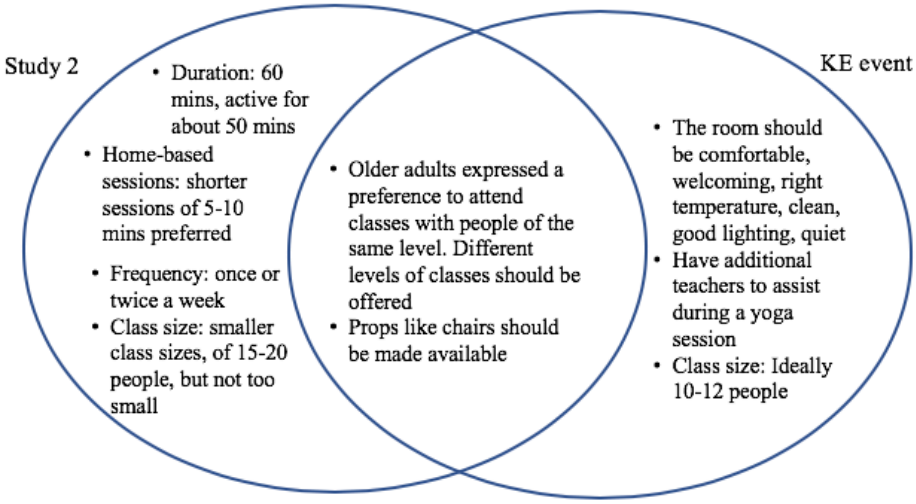


Figure 21. Other class details identified from Study 2 and the KE event

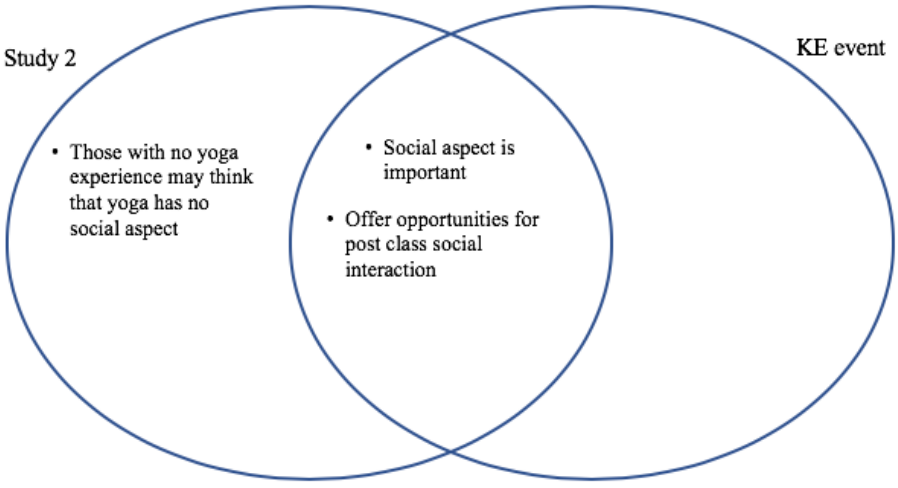


Figure 22. Social aspect elements identified from Study 2 and the KE event

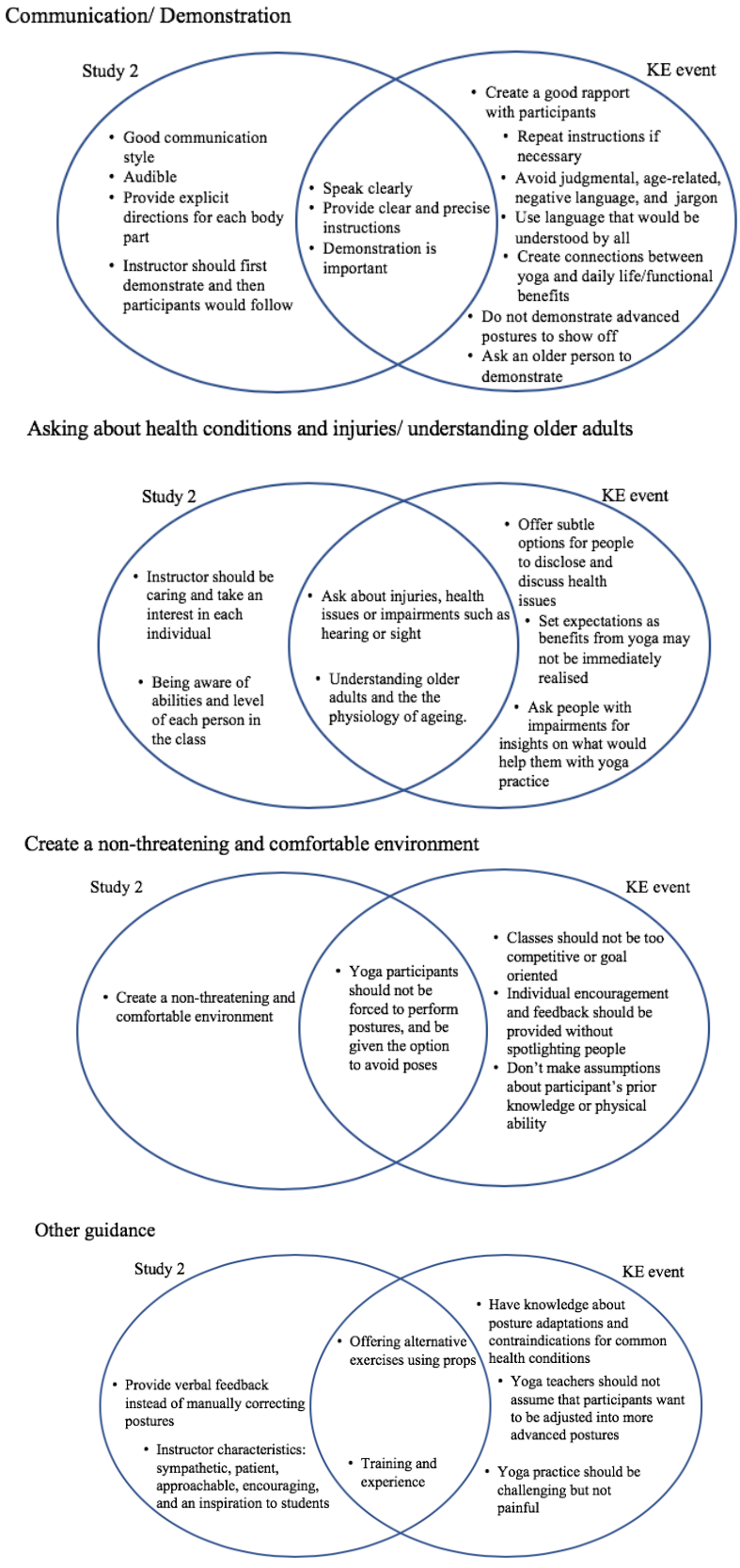


Figure 23. Guidance for instructors identified from Study 2 and the KE event

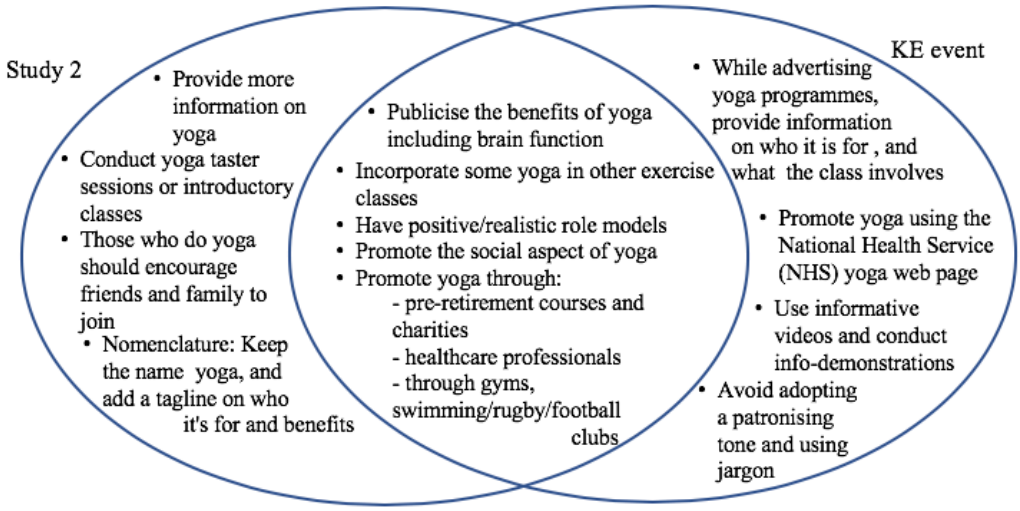


Figure 24. Yoga promotion strategies identified from Study 2 and the KE event

Reasons for the gender bias were also identified in Study 2 (Figure 18). Several strategies to encourage male participation were suggested by older adults in Study 2 including promoting yoga through football/rugby/swimming clubs and gyms, having role models for men, promoting the benefits of the social aspects of yoga, and reducing spiritual content. Study 2 and KE event participants stressed on the importance of having positive, relatable role models for men as a method to encourage participation. KE participants also felt that ensuring classes were progressive and establishing a way to make students aware of progress, would make yoga more appealing to men. Emphasising the benefits of yoga such as help with injuries and improving sporting ability would also attract men.

4.4.2 Comparison with previous literature. This section discusses findings in the context of previous published literature. Some studies have been described earlier (Humberstone & Cutler-Riddick, 2015; Nayak et al., 2015; Patel et al., 2011; Wertman et al., 2016). A study published 7 years ago, providing guidelines for healthcare professionals and yoga instructors to follow while working with older adults specifically to promote psychological health (Bonura, 2011) is also pertinent here. These guidelines were based on the author's experience as a yoga teacher and researcher in Minneapolis, US. The author commented on class environment, class

format and delivery, yoga practices and contraindications. The importance of synergies between yoga instructors and healthcare professionals was also discussed.

4.4.2.1 Perceived benefits. A number of perceived benefits were mentioned by both YPs and NYPs. The YP group reported perceived physical and mental benefits from practicing yoga, some of which were also reported by the NYP group. Although it has been reported that older adults are less likely to perceive a positive health benefit from yoga (Wertman et al., 2016), this is in comparison with middle aged adults and should not be interpreted to mean that they do not observe any health benefits at all. Some benefits mentioned by participants in the current study such as improved strength, balance, posture, sleep, mental ability, relaxation, help with joint problems, and social benefits were also identified in another study (Nayak et al., 2015). Other benefits like lowered blood pressure, immune response and preventing chronic fatigue were also reported by Nayak et al. (2015), which were not mentioned by the participants in the current study. This could be explained by differences in data collection methods, as Nayak et al. (2015) administered a survey. While the survey could not be accessed, it was evident from the published manuscript (Nayak et al., 2015) that some benefits were proposed in the survey. In Study 2, perceived benefits were explored with no specific prompts, and only those mentioned during the course of the focus groups and interviews have been reported. Better sleep, improved mobility, balance and strength, reduced pain, feeling relaxed and social benefits were also reported by older adult participants during the 12-week follow up in the study by Patel et al. (2011) . Reduced fear of falls was reported as a perceived benefit in Patel et al. (2011), but not by Study 2 YPs, although improved balance and mobility were mentioned. Reduced use of pain medication was another benefit mentioned in the study by Patel et al. (2011), which was not mentioned in Study 2. No information on chronic diseases or medication history of Study 2 participants were collected and hence no explanations can be ventured for this discrepancy between the two studies. Additional benefits were reported by participants at one-year follow up (Patel et al., 2011) including improved confidence and reduced anxiety, which were also observed in the current study. However, other benefits like reduced feelings of depression, more harmonious relationships and spiritual themes like feeling more in touch with oneself, praying more and helping with meditation (Patel et al., 2011) were not reported in the current study. The benefits mentioned at one-year follow up in the study by Patel et al.

(2011) seem to be more personal in nature. Since participants have been a part of the study for a longer period with greater interaction with the researchers and each other, they may have grown more comfortable talking about these aspects during focus groups. Hence while the current study has identified physical, mental and social benefits, Patel et al. (2011) also identified spiritual themes. Yoga offers a host of benefits and individuals are likely to pursue yoga to achieve varied objectives. It is not surprising that while some perceived benefits were mentioned across all studies, some differences were noted.

4.4.2.2 Apprehensions with yoga and suggestions to address them. Several barriers to yoga participation were identified among participants with no yoga experience. Some participants felt that they might find yoga difficult and demanding. To counter this, it was suggested in the KE event that options for seated exercise be provided. Study 2 participants also suggested that extreme and complicated movement should be avoided. Both these recommendations were supported by Bonura (2011).

Fear of embarrassment was cited as a barrier to participation in yoga by the NYP group. Contrastingly, Wertman et al. (2016) found that older adults were less likely to view social embarrassment or anxieties as barriers to participating in yoga than middle-aged adults. However, when comparing between studies it is important to keep in mind that participants in the Wertman study (Wertman et al., 2016) were all yoga practitioners. Older adults with higher levels of social anxiety may not have taken up yoga in the first place, and hence would not be included in the study. NYP participants from Study 2 were recruited from classes run by the local leisure centre including non-activity classes such as singing. Due to the inclusion of older adults with no yoga experience, as well as those with lower activity levels (21% reported low PA levels), some apprehensions such as fear of embarrassment may have been captured in Study 2. It was suggested in the current study that instructors should strive to create a non-threatening and comfortable environment for older adults. Not forcing or pushing yoga students to perform postures in class was emphasised in the KE event as well. Participants at the KE event felt that classes should not be goal oriented and that competitiveness should not be encouraged. Bonura (2011)

suggested moving away from achieving the perfect posture and shifting focus to improving health and wellbeing. Offering posture modifications and alternate exercises using props for those who are unable to perform certain postures was appreciated by participants in Study 2. This was endorsed at the KE event as well as by Bonura (2011), who suggested providing chairs to those who cannot sit on the floor, or need support for standing exercises. Participants in the study by Patel et al. (2011) appreciated the use of props during postures such as belts to help increase the range of motion and chairs and for support.

NYPs also felt that they may shy away from yoga due to the meditative and spiritual aspects. The findings in the study by Wertman et al. (2016) were along the same lines, with older adults less likely to take up yoga to explore spirituality and meditation than middle aged adults. However YPs in Study 2 mentioned that they found breathing and relaxation exercises useful and enjoyable, as did participants in the study by Patel et al. (2011). The importance of breathing and relaxation was emphasised by Bonura (2011) and in the KE event. The corpse pose was considered essential by those who participated in Study 2 as well in the KE event. Hence some spiritual, breathing, relaxation and meditative content in a yoga session is recommended but not too much. Wertman et al. (2016) reported that older men were more likely to participate in yoga for the physical benefits, while women cited meditative and psychological aspects. However, in the current study, both men and women observed that breathing and meditation played only a subordinate role.

4.4.2.3 Guidance for instructors. Strategies to communicate effectively while working with older adults were suggested in Study 2. These included being audible, giving clear and precise instructions, providing explicit directions for each body part, and demonstrating. At the KE event, repeating instructions if required was suggested. Being sensitive to the language used and using negative, judgemental, age-related languages was discouraged. Avoiding jargon and the use of eastern languages if yoga students were not comfortable was advised (KE event; Bonura (2011)). Demonstrating was found to be extremely important to older adults, and it was suggested in Study 2 that that the instructor demonstrates first, and then students

would follow. If the instructor was young, requesting older adults to demonstrate was a strategy suggested at the KE event. Bonura (2011) suggested mirroring the audience while demonstrating. Manually correcting postures should be discouraged based on Study 2, and this was finding was corroborated by Bonura (2011). Participants at the KE event warned against assuming that older yoga students want to be adjusted into more advanced positions. Training and experience of the yoga instructor has been found to be very important in Study2 and at the KE event, as well as in several other studies (Bonura, 2011; Nayak et al., 2015).

4.4.2.4 Other class details. Participants with no yoga experience preferred shorter yoga classes, and one hour was the preferred duration of each yoga session. Lack of time and long classes were found to be barriers to yoga participation (Nayak et al., 2015; Wertman et al., 2016) , and the suggestion of one-hour classes would address this barrier.

4.4.2.5 Strategies to promote yoga in an older adult population. Older adults with no yoga experience expressed lack of awareness and confusion around what yoga entails, which types of yoga are suitable to older adults, what to wear in a yoga class, and the benefits of yoga. One major strategy to promote yoga that would address many of these perceived barriers is to provide more information around yoga. Media cues such as television programmes, and posters have been cited as triggers to take up yoga in older adults (Nayak et al., 2015; Wertman et al., 2016). From Study 2 and the KE event, several other strategies have been compiled including offering taster sessions and introductory classes, incorporating some yoga into other exercise classes and activities, promoting yoga at pre-retirement courses and charities, and providing info-demonstrations. Encouraging people who do yoga to get others in was a suggested strategy, which is supported by quantitative and qualitative data showing that older adults were likely to be influenced by the recommendation from a neighbour, family or friends to take up yoga (Nayak et al., 2015; Wertman et al., 2016). Using realistic pictures, not adopting a patronising tone while marketing to older adults, and having positive role models was also suggested during the KE event. Working with healthcare professionals to promote yoga, and

getting them more involved in yoga activities such as demonstrations was recommended. This would also enable yoga instructors to take medical history into account to identify postures that may be contraindicated for various health conditions. Working with healthcare professionals was emphasised by Bonura (2011) who also recommended that healthcare professionals should review published literature around yoga and be informed about the benefits of yoga.

These suggested strategies could be used to recruit older adults for yoga research. One RCT (Tew et al., 2017) that was included in the systematic review (Study 1) had employed several of these suggested strategies. Of the 52 participants recruited, 11 (21.2%) heard about the study through taster sessions at an Arthritis Care meeting, community centres, and a residential care home; 10 (19.2%) through friends/relatives of people at a yoga centre and a yoga E-newsletter; 8 (15.4%) through leaflets delivered door-to-door in areas with a high concentration of older people, and; 1 (1.9%) through information displayed in a general physician's surgery. Though no further information on description or evaluation of recruitment methods were available, the study provided evidence that the suggested yoga promotion strategies were viable recruitment tactics.

4.4.3 Strengths and limitations. A significant strength of this phase (Study 2 and KE event) is that the target population as well as other stakeholders (yoga instructors, studio owners, programme coordinators, and academic researchers) were consulted, allowing the collection of diverse thoughts, suggestions and strategies (Nutbeam & Bauman, 2014). These data are extremely useful in designing an appealing, appropriate, and acceptable yoga programme, and would aid the development of strategies to encourage yoga participation.

A key strength of Study 2 is that this is the only published qualitative study to date which captures the perceptions of older adults with no previous yoga experience. Including these participants helped understand and address many barriers to yoga participation. The study also makes practical recommendations, which were shared with those who could implement them such as yoga teachers and studio

owners. The main limitation of Study 2 is that the sample does not cover all socio-economic and geographical segments in Scotland. Moreover, the sample included older adults with higher PA levels. This may limit the generalisability of findings. Men formed a smaller proportion of the sample due to recruitment difficulties, despite adopting alternative recruitment strategies such as one-on-one interviews. Men are typically under-represented in yoga research (Nayak et al., 2015; Patel et al., 2011; Wertman et al., 2016). However, the perceptions and preferences of male older adults were analysed and reported in Study 2. Those who are completely averse to yoga may not have participated, and hence the study may have only captured perceptions of those with some degree of interest and enthusiasm.

The KE event is a novel method of data collection and created an atmosphere conducive to knowledge sharing which was more effective than a conventional researcher-participant format. The KE event was also an opportunity to promote research uptake that would ultimately lead to research impact (Morton, 2015). The systematic review and meta-analysis in Chapter 3 established that yoga is effective in improving strength and balance. To improve adherence to MS and BC guidelines among older adults, yoga teachers need to be made aware of these guidelines and the role of yoga in bringing about these improvements. The KE event was designed as a two-way exchange, and achieved the twin objectives of sharing new research evidence as well as procuring insights from another group of stakeholders. It also enabled the creation of a network of individuals interested in yoga for older adults, and would be useful for future dissemination of knowledge.

While the KE event adds extremely valuable information, this section would have benefitted from the use of rigorous data collection techniques. For example, it was noted that the data collected from the KE event on home-based sessions was sparse. Data collection on all elements of interest could have been ensured by using a guide similar to a focus group discussion or interview. Moreover it was not possible to attribute the data collected to a particular group of stakeholders (yoga teachers, studio owners, researchers). Establishing methods to identify speakers or

contributors would have provided a better understanding of the recommendations collected at the KE event.

4.5 Conclusion and Next Steps

Through consultations with the target population and other stakeholders, several themes have been identified including apprehensions with yoga, reasons for the gendered nature of yoga participation and strategies to address this, class content preferences, guidance for instructors, social interaction, and other class details (including frequency, duration, class size, age and level of participants, and class environment). Strategies to promote yoga in an older adult population were also identified. In the next chapter, some barriers and themes identified in this chapter will be tested through further consultations with older adults.

Chapter 5. Evaluating and Refining Intervention Components

5.1 Introduction

The objective of this PhD project is to develop an appealing, appropriate and acceptable yoga programme for older adults in Scotland, that would be further tested and evaluated before implementation. Formative evaluation is a part of intervention development that includes pilot testing the intervention material to check if it is acceptable and useful to the target population (Nutbeam & Bauman, 2014). The value of formative evaluation has been emphasised in previous chapters (sections 1.20, 3.1). In Study 2, perceptions of yoga in this population were explored, and findings included understanding the apprehensions that older adults with no yoga experience may have with respect to yoga participation, guidance for instructors and strategies to promote yoga in the older adult age group. Several barriers/themes influencing yoga participation were identified in Study 2 (Table 17). In this chapter, the intervention development process is continued with further consultations with the target population. The current chapter aims to develop and test intervention components to address these barriers/themes.

Table 17

Barriers and themes identified in Study 2

Barriers/themes types	Barrier and themes identified in Study 2
Overall Barriers:	
1	Will find yoga difficult and demanding
2	Apprehensions about continuous movement between standing and floor
3	Apprehensions about meditative/spiritual aspect
4	Fear of embarrassment/creating a non-threatening environment
5	Lack of information on yoga
6	Lack of aerobic element
7	Pictures are usually of young and supple models
8	Perception that yoga lacks a social element
Home-based themes:	
9	Handouts can be used to encourage home-based practice
10	Older adults occasionally do breathing exercises at home
11	Pictures in handouts are usually of young people
Home-based barriers:	
12	No time/may do a shorter session
13	Practicing yoga at home without an instructor could lead to injuries

Three modes of delivering the intervention components were selected-

I. Conducting yoga taster sessions

II. Promoting yoga to older adults using leaflets

III. Home-based practice supported by home-based yoga handouts

5.1.1 Selection of taster sessions as a mode of delivery. To my knowledge, no previous studies have reported on the development and delivery of yoga taster sessions. A Medline database search conducted in October 2018 using terms relating to yoga (Yoga/ or Yoga.tw or Asana.tw or Pranayam*.tw or Dhyan*.tw) and taster or sample sessions (taster*.tw or sample class*.tw or sample session*.tw or sample yoga*.tw or yoga sample*.tw) did not return any studies. Only one RCT (Tew et al., 2017) included in the systematic review (Study 1) reported using taster sessions as a recruitment strategy, with 21.2% of the 52 participants learning about the study through taster sessions conducted at an Arthritis Care meeting, community centres, and a residential care home. However, no further details on taster sessions as a

recruitment or promotion strategy was provided in the study. Conducting yoga taster sessions was suggested as a promotional tactic in Study 2, and has been selected as an innovative strategy to increase awareness and promote yoga participation among older adults in the current study (Study 3). The taster sessions were also used as a mode to incorporate and test the programme intervention components (described under methods), designed to address some of the identified barriers and themes (Table 17).

5.1.2 Selection of leaflets as a mode of delivery. Designing and evaluating a leaflet as a means to increase awareness about yoga formed a second part of Study 3. Since providing information verbally to an older adult population could have limitations such as poor recall and retention, providing written information is preferred while communicating health messages (Sadowski, 2011). Infographics using text and illustrations can be an effective way to communicate health messages (Scott, Fawkner, Oliver, & Murray, 2016). A recent example is the infographic of the physical activity guidelines for adults and older adults developed and launched by the Chief Medical Officers' in the UK (Department of Health, 2016). Media cues such as posters have been found to be instrumental in initiating yoga among older adults (Wertman et al., 2016). Moreover, 26% of those aged 65-74 years and 61% of those over 75 years in the UK still do not regularly access the internet (Age UK, 2016). A leaflet can be distributed online or can be handed out as a hard copy, and can also be displayed as posters. Using leaflets as a recruitment strategy was mentioned by only one RCT (Tew et al., 2017) included in the systematic review (Study 1), with 15.4% of the 52 participants learning about the study through leaflets delivered door-to-door in areas with a high concentration of older people. The study (Tew et al., 2017) shows that using leaflet for recruitment is a viable strategy. However, no further details on the content and of the leaflet were provided. Using leaflets as a method to address the barrier of lack of information on yoga has been explored in this study.

5.1.3 Selection of home-based exercises as a mode of delivery. Home-based exercises have been found to be effective in improving several physical and

psychological outcomes. Participating in home-based exercises improved aspects of physical function of frail older adults in a study with a single-arm pre-post test design (Matsuda, Shumway-Cook, & Ciol, 2010). Seventy-two older adults participated in a six-week home-based exercise programme where they performed progressive strength training twice a week for 15 to 20 minutes, balance and gait training thrice a week for 15 to 20 minutes, and endurance activity thrice a week for up to 30 minutes. Improvements in lower and upper body strength and mobility were observed (Matsuda et al., 2010). A systematic review assessed the effectiveness of home-based resistance training interventions in improving strength and functional ability in older adults (Thiebaud, Funk, & Abe, 2014). Eight RCTs were included in the review, of which knee extension strength was significantly improved in five studies, and functional ability was significantly improved in seven studies. Four studies also included some class-based sessions supervised by qualified trainers. Authors concluded that home-based exercise could bring small improvements to strength and functional ability.

Participants in Study 2 expressed a preference for class-based over home-based practice. However, home-based exercise programmes can address several barriers to physical activity participation among older adults such as social anxiety and lack of facilities or classes (Mutrie, Blamey, Davison, & Kelly, 1993). A study conducted in Scotland published 25 years ago aimed to address these issues and compared adherence rates of older adult participants in class-based and home-based exercise programmes (Mutrie et al., 1993). At six months follow up, no statistical difference in adherence was found between the home-based group (66%) and class-based group (71%). The study recommended promoting home-based programmes in areas without adequate exercise facilities, and using a home-based programme to supplement activities of those who attend class-based sessions. Another study compared class-based and home-based exercise training in sedentary older adults (King, Haskell, Taylor, Kraemer, & DeBusk, 1991). Three hundred and fifty seven participants were randomly assigned to one of four groups: (i) higher-intensity class-based exercise (ii) higher-intensity home-based exercise (iii) lower-intensity home-based exercise or (iv) control. Class-based participants were encouraged to attend

three 60-minute classes a week. High intensity home-based training also consisted of three 60-minute exercise sessions per week, and the lower intensity home-based group were instructed to complete five 30-minute sessions per week. All three exercise groups showed significant improvements in VO_2 max and duration in the treadmill exercise test at 6 and 12 months compared with controls, with no significant difference between the three groups. Adherence to exercise was higher in the home-based exercise group compared to the class-based group at 12 months. The results of these two studies (King et al., 1991; Mutrie et al., 1993) emphasise the importance and potential of home-based exercise in maintaining adherence rates in the long run. Allen and Morey (2010) examined factors affecting adherence to PA. They reported that programme-related factors such as home-based or class-based sessions could influence adherence. They highlighted research evidence demonstrating that home-based exercise is associated with greater adherence and higher levels of activity. Authors also drew attention to certain personality types that prefer home-based classes. However, authors observed that both settings could have important roles to play in improving adherence. Contrary to the finding that adherence rates are higher in home-based programmes, a systematic review examining factors associated with better adherence (Picorelli, Pereira, Pereira, Felício, & Sherrington, 2014) found that adherence to class-based sessions was higher than home exercises. Authors noted that this may impede the widespread implementation of exercise programmes. A suggested feasible and cost effective solution was to combine group and home-based sessions.

These findings are relevant to the current study. Some participants in Study 2 mentioned doing yoga at home in addition to attending classes. They also felt that home-based sessions may be helpful if they were unable to attend classes for any reason. Since home-based sessions have an important role to play in maintaining adherence and improving health outcomes, this aspect was included in Study 3 in addition to class-based taster sessions. Intervention components pertaining to a home-based yoga session were evaluated as a part of Study 3.

Handouts and brochures with illustrations and text have been used as a part of home-based exercise programmes for older adults (Mian et al., 2007; Yates & Dunnagan, 2001). Yates and Dunnagan (2001) conducted a RCT to evaluate the effectiveness of a 10-week home-based fall risk reduction programme on physical and psychological outcomes in rural older adults in Montana, US. Participants in the intervention group took part in a home-based exercise programme, received fall risk and environmental hazards education, and nutrition counselling. Participants were given an hour-long introduction to the programme and were taught how to do the exercises properly. Participants were then given a brochure with visuals and text, which they were encouraged to follow to complete the home practice. Recommended frequency of practice was three times a week, and each session took approximately 15 minutes. 72.2% of the home-based group exercised at least 12 times over the 10-week intervention period. Statistically significant improvements in balance, bicep endurance, lower extremity power, and falls efficacy were found for the intervention group compared to the control group. Since it was a multi-factor programme, it is not possible to attribute effectiveness to any one programme component. However, the study is an example of an effective home-based programme supported by a brochure. Home-based handouts have been used in several yoga interventions to support independent yoga practice (Oken et al., 2006; Tew et al., 2017). Participants in Study 2 discussed the pros and cons of materials like handouts and videos to support their home practice. Participants felt that handouts would provide structure and serve as a reminder for home-based practice. Although some participants felt that videos would be easier to follow and more motivating than handouts, negatives included difficulties in accessing videos because of not owning a computer, irregular or no internet access, and lack of video facilities in their exercise space. Ideally, both videos and handouts should have been developed as material for home practice to cater to varied preferences. However, this could not be undertaken due to time and cost constraints. A home-based handout was chosen as the medium to support home practice as it could be used by all older adults.

5.1.4 Instructor's experience. A yoga taster session was selected as a mode of delivery within which several intervention components were incorporated. Since

the instructor is the medium through which an intervention is delivered, it is important to assess whether the intervention components are easily understood and translated to practice by the instructor. This was also an opportunity to procure feedback on whether the information provided to the instructor was sufficient. Feedback on the delivery of the intervention, and suggested amendments and improvements to intervention components could also be procured. Understanding the instructor's experience of delivering the intervention is key to effective implementation.

The objectives of Study 3 are (a) to assess whether the yoga intervention components delivered through taster and home-based sessions are appealing, appropriate and acceptable to an older adult population (b) to procure feedback on taster sessions and leaflets as strategies to promote and encourage yoga participation (c) understand the instructor's experience of delivering the taster session, and (d) to compile suggestions to further refine the yoga programme.

5.2 Methods

5.2.1 Development of resources. The taster session, leaflet and home-based handout were designed by the lead researcher, and reviewed by the research team (GB, CF), members of the PhD steering group (ML, NM, JA) and Claire Craig (Health & Physical Activity Manager, Edinburgh Leisure). The barriers/themes, the corresponding intervention components to address these, and the mode of delivery (taster session, leaflet, home-based session) are summarised in Table 18 and elaborated below.

5.2.1.1 Taster sessions. In Study 2, taster sessions were suggested as a strategy to encourage yoga participation by older adults with no yoga experience. The sessions would provide the target group an opportunity to sample yoga and assess their affinity for the programme. Several intervention components to address barriers/themes to yoga participation were incorporated within the taster session. The taster session was created based on the following components-

1. Components to address apprehensions of finding yoga difficult and demanding.

(i) Adopt a gentle pace. All participants in Study 2 preferred a gentle pace in a yoga class. This was suggested by participants at the KE event as well. A study included in the systematic review (Tew et al, 2017) followed the British Wheel of Yoga Gentle Years Programme, which was conducted at a slower pace. The yoga group in the study saw improvements in several parameters compared to the control group, and adjusting the pace to make it suitable for an older population did not dilute the benefits of yoga. The taster session in the current study was hence designed to be conducted at a gentle pace.

(ii) Use props (like chairs). Study 2 participants emphasised the importance of props for supports for those unable able to perform certain postures. This was also suggested by participants at the KE event. Hence the taster sessions included the option of using chairs to perform certain postures.

(iii) Avoid complicated movements. Participants with no yoga experience felt that they may struggle with yoga, and did not want complicated twists and turns. The yoga programmes in most studies in the systematic review (Study 1) were tailored for older people, with simple but effective postures. Postures employed by studies in the systematic review (Study 1) were used in the taster sessions so that intervention effects would not be diluted.

(iv) Instructors should suggest appropriate posture modifications and alternatives. It was deemed important to yoga participants in Study 2 that the yoga instructor suggested alternatives and modifications to postures that they were not comfortable performing. Participants at the KE event also felt that this was essential.

2. Components to address apprehensions about continuous movement between standing and getting down on the floor.

(i) Avoid continuous movement between sitting/lying down and standing up. Participants with no yoga experience were apprehensive about continuous movement

between lying down or sitting on the floor and standing up. For the yoga taster session, standing/sitting postures on a chair, and lying down postures were clustered as separate groups. All seated postures were to be done using a chair. Reclining poses were grouped together towards the end of the session, and could also be performed while seated on a chair.

3. Components to address apprehensions about meditative/spiritual aspect.

(i) Include some breathing and meditation but not too much. Getting the right amount of breathing and meditation is important, as participants wanted some but not too much breathing/meditation/spiritual content. At the same time, participants who had done yoga felt that breathing was beneficial. Attendees at the KE event advocated incorporating breathing, meditation and relaxation techniques.

4. Components to overcome participants' fear of embarrassment and create a non-threatening environment.

(i) Instructor should convey that participants could choose their own pace during the session, and should not feel forced to perform postures. Participants in Study 2 felt that they needed to feel comfortable choosing their own pace. They also did not want to be pressured to keep up with the class, or forced to perform postures they were not comfortable with. The instructor should try to create a non-threatening atmosphere, where participants did not feel intimidated, judged or embarrassed.

(ii) The instructor should ask the participants if they have any injuries or health conditions. Participants in Study 2 who had done yoga previously appreciated instructors being caring, taking an interest in each student and asking about any injuries or health conditions that people in the class might have.

5. Components to overcome lack of information on yoga.

(i) Taster session as a yoga promotion strategy. A taster session would give participants who had never done yoga a chance to experience it. Some older adults in Study 2 had no idea what yoga was about, and a taster session provided an opportunity to participate in yoga.

6. Components to overcome lack of aerobic element.

(i) Taster session used to bring attention to other benefits of yoga.

Participating in a taster session would allow older adults who were not familiar with yoga to experience other physical and mental benefits of yoga.

5.2.1.1.1 Taster session content. Participants in Study 2 were comfortable with a class structure that started with warm up exercises, followed by the main activity including stretches, and ending with cool down and relaxation. A taster session exemplar consisting of some postures from studies included in the systematic review (Study 1) was created. The study by Tew et al.(2017) was used as a primary reference in the creation of the taster exemplar as it was a recent study and the only yoga RCT in the systematic review to be delivered in the UK. Moreover, the yoga programme used in the Tew et al. study (British Wheel of Yoga Gentle Years Programme) was adapted for older adults and was consistent with many of the elements discussed in Study 2, such as adopting a slower pace and using chairs for support. The taster session structure and postures are presented in Figure 25. The six main postures mentioned in the taster exemplar (one-foot balance, warrior pose, chair pose, triangle pose, cat-cow on chair and downward dog on chair) are attached as pictures in the supplementary section (Appendix 26)

Warm up:
(i) Coordinated breath and hand movement: stretch hands forward, and stretch hands up
(ii) Seated on chair: rotations- neck, shoulder, wrist, ankles
(iii) Seated on chair: forward bend with one leg stretched out
(iv) Standing up warm up movements: side stretches, hip rotation, standing spinal twist

Postures:
(i) One-foot balance
(ii) Warrior pose
(iii) Chair pose
(iv) Triangle pose
(v) Cat-cow on chair
(vi) Downward dog on chair

Cool down:
(i) Reclining one knee to chest
(ii) Reclining spinal twist
(iii) Reclining leg on wall
(iv) Corpse pose
Note: all reclining postures can be performed seated on a chair

Breathing:
(i) Abdominal/ diaphragmatic breaths
(ii) Muscle relaxation in corpse pose

Figure 25. Taster session structure and postures developed by the lead researcher based on studies included in the systematic review (Study 1)

5.2.1.2 Leaflet. Lack of information on yoga was identified as a barrier to participation among older adults. A leaflet on yoga was developed as a method to overcome this barrier. This was created based on the following components:

1. Component to address the barrier of lack of information on yoga.

(i) Provide information on the benefits, and other aspects of yoga. The leaflet could be used to provide information on the benefits of yoga. Lack of information on yoga was identified as a barrier to participation, and KE participants suggested providing information on the benefits of yoga specific to older adults, including benefits related to brain function.

2. Component to address the barrier of lack of aerobic element.

(i) A leaflet could be used to increase awareness of the benefits of yoga in improving MS and BC. Lack of aerobic element was mentioned as a barrier to participation in Study 2. Leaflets could be used to increase awareness of MS and BC recommendations, and also provide information on the other benefits of yoga including strength and balance.

3. Component to address the barrier of fear of embarrassment.

(i) A leaflet could be used to convey the non-competitive aspect of yoga. Participants with no prior yoga experience were worried that they would feel embarrassed in a yoga class, and apprehensive that they would find the postures difficult. Hence, conveying that yoga is non-competitive, and could be taken at one's own pace is important. Quotes from participants who do yoga could be used to convey the non-competitive aspects of yoga.

4. Component to address the view that yoga pictures are usually of young and supple models.

(i) Include appropriate pictures of older people in simple postures. Study 2 participants felt that books and handouts on yoga have pictures of young and supple girls and are not reflective of their age group. Participants with no prior yoga experience felt that yoga is portrayed in media as an activity with contortions and difficult postures. Hence, it was considered important that the leaflet contains pictures of older adults in simple, achievable postures. Using realistic pictures was suggested during the KE event as well.

5. Component to address the perception that yoga lacks a social element.

(i) Mention opportunities for social interaction. Participants in the qualitative study who had previously attended yoga classes expressed that social interaction was a very important aspect of yoga participation, and they enjoyed catching up over coffee after the yoga class. However, those with no yoga experience felt that yoga might not have a social element. Mentioning this aspect in the leaflet would make potential participants aware of this dimension of yoga.

A one-sided leaflet was designed based on these components and is attached as Figure 26.

Figure 26. Leaflet used in Study 3

5.2.1.3 Home-based sessions. Participants in Study 2 felt that home-based sessions could be useful for beginners or for those who were unable to attend classes. The home-based session and accompanying handout were developed based on the following components-

1. Component to address the barrier of lack of time.

(i) Shorter duration of home-based session (5-10 minutes). Participants in Study 2 conveyed that they may not do a full yoga session at home, but may do a shorter session of 5-10 minutes.

2. Handouts can be used for home-based practice.

(i) Provide a handout that older adults can refer to during their home-based session. In Study 2, handouts were considered to be a useful tool for home-based practice by older adult participants. As mentioned earlier, they felt that handouts would provide structure and serve as a reminder.

3. Component to address the view that practicing yoga at home without an instructor could lead to injuries.

(i) The home-based handout should contain postures that participants would have already done under the guidance of the instructor. Participants in Study 2 felt uneasy about doing yoga at home without an instructor, and would be more confident doing poses that they had already done in class under the guidance of the instructor.

4. Component to include the finding that older adults occasionally do breathing exercises at home.

(i) Incorporating some breathing within the home-based session. In Study 2, some participants with yoga experience mentioned that they do some breathing exercises at home, and they found that it could be very relaxing and calming.

5. Component to address the view that pictures are usually of young and supple people.

(i) Incorporate relevant pictures of older adults in the home-based handout. Participants felt that books and handouts have pictures of young and supple girls, and they would like to see people of their own age represented in the handouts. KE event attendees also reiterated the importance of having positive, relatable role models.

Based on these components, a short 5-10 minute home-based yoga session was designed. The home-based handout featured pictures of older adults. Four exercises that the instructor covered during the taster session were included in the handout. Since participants were new to yoga, and would have just attended one yoga taster session, simple postures performed using a chair as a prop were chosen. One posture to promote flexibility, one for balance, and one for strength were included. Based on the finding that older adults do some breathing at home, one breathing exercise was also included. The single-sided home-based handout that was developed for Study 3 is attached as Figure 27.

Figure 27. Handout used for home-based sessions in Study 3

Table 18

Summary of themes/barriers identified in Study 2, corresponding intervention components to address them, and the mode of delivery

Themes/barriers	Components addressing the themes/barriers and mode of delivery
Will find yoga difficult and demanding	Taster session: Adopt a gentle pace
	Taster session: Use props (like chairs)
	Taster session: Avoid complicated movements
	Taster session: Instructor should suggest appropriate posture modifications and alternatives
Apprehensions about continuous movement between standing and floor	Taster session: Avoid continuous movement between sitting/lying down on the floor and standing up. Group the standing postures together separated from sitting/lying on the floor
Apprehensions about meditative/spiritual aspect	Taster session: Include some breathing and meditation but not too much
Fear of embarrassment/creating a non-threatening environment	Taster session: The instructor should ask the participants if they have any injuries or conditions
	Taster session: Instructor should convey that participants can take it at their own pace during the session, and they should not feel forced to perform postures
	Leaflet: Quotes in the leaflet should convey the non-competitive aspect of yoga
Lack of information on yoga	Taster session: Taster session as a strategy to increase awareness of yoga Leaflet: Provide information on the benefits, and other aspects of yoga
Lack of aerobic element	Leaflet and taster session: Used to increase awareness of other important benefits of yoga like muscle strength and balance
Pictures are usually of young and supple models	Leaflet: Include appropriate pictures of older people in simple postures
Perception that yoga lacks a social element	Leaflet: Mention opportunities for social interaction
Home-based exercise: Handouts can be used to encourage home-based practice	Home-based practice: Provide a handout that older adults can refer to during their home-based session
Home-based exercise: No time/may do a shorter session	Home-based practice: Shorter duration of session (5-10 minutes)
Home-based exercise: Practicing yoga at home without an instructor could lead to injuries	Home-based practice: Include postures that participants have already performed under the guidance of the instructor
Home-based exercise: Older adults occasionally do breathing exercises at home	Home-based practice: Incorporate some breathing
Home-based exercise: Pictures in handouts are usually of young people	Home-based practice: Include pictures of older adults

5.2.2 Study design. Eldridge et al. (2016) developed a conceptual framework for defining pilot and feasibility studies. In this framework, it was suggested that a feasibility study should be undertaken when there is uncertainty about the viability of

an RCT (Eldridge et al., 2016). Feasibility was described as an overarching concept (Figure 28) within which three types of studies were identified. These included:

(i) Randomised pilot studies: Studies which are a smaller scale version of a future RCT, or parts of it. While these studies mostly reflect the design of a future trial, they may try out alternative strategies (for example with respect to data collection for outcome measurement).

(ii) Non-randomised pilot studies: These are studies in which all or part of the intervention to be evaluated and other processes to be undertaken in a future trial are carried out (piloted), but without randomisation of participants. The design could cover studies similar to randomised pilot studies except that the intervention and control groups have not been randomised, as well as studies in which only the intervention, and no other trial processes, are piloted.

(iii) Feasibility studies that are not pilot studies: In these studies, investigators do not implement the intervention to be evaluated or other processes to be undertaken in a future trial. However, they are still attempting to answer a question about whether some element of the future trial is feasible and they may be addressing intervention development in some way. A study in which surgeons and patients were asked about the feasibility of randomisation has been cited as an example. Other examples cited were interviews to ascertain the acceptability of an intervention, or questionnaires to assess the types of outcomes participants might think important. The authors clarify that within the framework, these studies can be called feasibility studies but cannot be referred to as pilot studies, since no part of the future RCT is being conducted on a smaller scale.

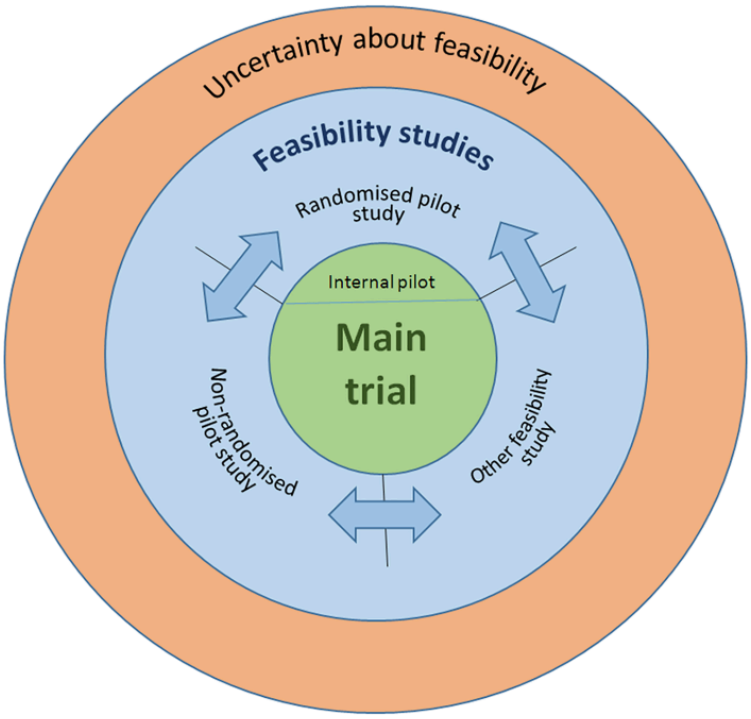


Figure 28. Feasibility- conceptual framework. Reprinted from "Defining feasibility and pilot studies in preparation for randomised controlled trials: Development of a conceptual framework" by Eldridge et al., 2016, PLoS ONE, 11(3), 16. Copyright [2016] by BMJ Eldridge et al. Permission not required under the terms of the Creative Commons Attribution License.

Based on these definitions, the current study can be categorized as a feasibility study (that is not a pilot study) since it aims to aid intervention development by ascertaining the appeal, appropriateness and acceptability of key intervention components.

The COnsolidated criteria for REporting Qualitative research (COREQ) checklist (Appendix 27) was adhered to while reporting on this study (Tong et al., 2007).

5.2.3 Recruitment strategy for feasibility study. Participants for the feasibility study were recruited through convenience sampling. A multi-level recruitment strategy was followed, with participants recruited from a local leisure centre, and a university fitness facility. Recruitment posters (Appendix 28) were displayed on university notice boards, supermarkets and cafes near the university

buildings, and charity shops. An email with information on the study was sent out to university staff and students. Twitter and word of mouth were also used as recruitment strategies. The study inclusion criteria were as follows-

- Male and female participants
- 65 years and over
- Hasn't participated in a regular yoga class previously
- Able to walk at least 10 metres without assistance from anyone
- Able to give informed consent and follow study instructions

A risk assessment exercise was undertaken, where falls and minor injuries during the taster session and home-based practice were identified as potential hazards (Appendix 29). Control measures put in place to reduce and manage risks included ensuring that the programme was designed specially for older adults, with slower pace and avoiding complicated movements, and ensuring that first aid was at hand in case of any adverse events. The project was classified as low risk after installing the requisite control measures. Based on this it was decided that it was not necessary to use the Physical Activity Readiness Questionnaire (PAR-Q) as a screening tool, or as a pre-requisite for participation. Participants were advised in the participant information sheet that if they were uncertain or had reservations about their ability to participate in the yoga taster session, they should consult their doctor before giving consent. Twenty-six people expressed interest, and there was a 35% dropout rate due to unavailability on the suggested dates.

The way that potential participants were contacted and approached varied with the recruitment venue and method. The lead researcher visited the university fitness facility and spoke to older adult participants after the conclusion of a fitness class they were attending. Participants were informed about the aims of the taster session, what it would entail and evaluation details. They were then given the participant information sheet (Appendix 30), and the lead researcher noted the contact numbers and email addresses of interested participants. She then coordinated with the participants through email to set up the taster sessions. For the local council-run leisure centre, all information including the participant information sheet was

delivered to potential participants through leisure centre staff. Participants contacted through word of mouth and emails (university staff and students) were provided with the participant information sheet via email.

Ethical approval for the study was obtained from an institutional ethics committee (approval letter included in Appendix 31). Participants gave written informed consent on the day of the taster session before the session commenced (consent form provided in the Appendix 32).

5.2.4 Intervention delivery and evaluation

5.2.4.1 Taster session delivery. A total of four taster sessions were conducted, of which two were conducted in a studio in the university fitness facility, one in a studio in a local leisure centre, and one in a large meeting room in a university building. The studios were equipped with mats, chairs and blocks. The meeting room was provided with chairs and mats. Participants first attended a half-hour yoga taster session. After the taster session, they moved to another room where an evaluation was conducted.

5.2.4.2 Taster session evaluation. The taster session was evaluated using mixed methods consisting of focus group discussions and a questionnaire. The primary evaluation method used was focus group discussions. Qualitative research is used to examine non-observable phenomena, and aids the discovery and interpretation of underlying meanings and patterns of relationships (Nutbeam & Bauman, 2014). Study 3 aimed to assess whether the intervention components were successful in creating an appealing, appropriate and acceptable programme. Adopting a qualitative approach would enable the collection of rich data to understand the experiences of older adults, and procure feedback to further refine the intervention. Focus groups are a recommended qualitative method for programme evaluation, possessing the strength of eliciting expected and unexpected information (Nutbeam & Bauman, 2014). This is important for the present evaluation, where understanding varied positive and negative responses to the intervention is essential. The focus group discussions were supplemented by a questionnaire to ensure that

individual level evaluation data on certain key aspects of the taster session were captured, and to reduce the amount of time dedicated to evaluation, effectively reducing participant burden and fatigue.

The focus group guide (Appendix 33) and questionnaire (Appendix 34) were developed by the lead researcher and reviewed by the supervisory team and steering group members.
The taster session topic guide addressed five main topics-
(i) General feedback about the session
(ii) Movement between standing up and getting down on the floor
(iii) Lack of aerobic element: since the strategy to address this barrier was to create awareness about the other benefits of yoga, participants were asked if they perceived yoga to be beneficial after attending the taster session
(iv) Breathing and meditation aspects of the taster session
(v) Comments on the instructor

The questionnaire consisted of four Likert scale-based items pertaining to enjoyment, feelings of embarrassment, difficulty, and intention to join future yoga sessions. The options for each item (for example, I enjoyed the yoga taster session) ranged from 1: Strongly disagree to 5: Strongly agree. Each item also had an open-ended component where participants could elaborate on their answer.

The evaluation of the taster session took approximately 30 minutes. Participants first completed the questionnaire during which tea, coffee and biscuits were provided. Following this, they participated in a focus group session to share their views on the yoga taster they had just attended.

5.2.4.3 Yoga leaflet. After the taster session and evaluation, participants were given the yoga leaflet (Figure 26) and time to read it (approximately 5 minutes).

5.2.4.4 Yoga leaflet evaluation. Focus group discussions were used to evaluate the leaflet. The focus group topic guide (Appendix 33) for the leaflet evaluation addressed:

(i) General feedback and usefulness of the leaflet

(ii) Design

(iii) Content

(iv) Language

(v) Pictures included

(vi) Whether the leaflet would motivate participants to attend a yoga class

5.2.4.5 Home-based yoga sessions and handout. Before the participants left, they were given the home-based handout (Figure 27). They were requested to follow the handout at home on at least two days in the following week.

5.2.4.6 Home-based yoga sessions and handout evaluation. To evaluate the home-based sessions and handout, the lead researcher conducted a one-on-one phone-based interview with the participants after one week. The date and time for this session was arranged with the participant after the taster session evaluation.

The phone interview guide (Appendix 33) for the home-based session addressed the following:

(i) Adherence: whether participants were able to complete the home-based session following the handout. If they were unable to do the session at home, then reasons were explored.

(ii) Ease of following the handout.

(iii) Whether the exercises were easy to do independently.

(iv) Whether participants would regularly practice the postures and breathing at home using the home-based handout.

(v) Whether other materials (for example a video) would help with home-based practice.

(vi) Whether participants experienced any injuries or discomfort while practicing yoga at home.

5.2.4.7 Yoga taster session instructor. It was decided that the lead researcher would not conduct the taster session as participants might find it difficult to provide honest feedback if the same individual delivered the session and conducted the evaluation procedures. Furthermore, an objective of Study 3 was to understand the instructor's experience of delivering the session, and to determine if an independent instructor was able to comprehend the intervention components and deliver the intervention effectively.

5.2.4.7.1 Instructor introduction. The taster sessions were delivered by an experienced yoga instructor. The instructor had been practicing yoga since 2000, and teaching yoga since 2004. He studied yoga and yoga-therapy in the British School of Yoga (2013). He established a yoga studio in Ukraine in 2004, where he taught and trained numerous yoga teachers. He worked as a scientific and methodical coaching expert in the field of rehabilitation and development of the musculoskeletal system in a major league football team in Ukraine. The work was focused on areas most vulnerable to injuries in athletes: lower back, hip joints, shins and knees. In his classes he draws from his knowledge of anatomy and yoga techniques, and emphasises correct alignment in postures. He conducts seminars and master-classes on yoga in the UK, India, Ukraine and other countries. While he had not taught a yoga class exclusively for older adults, he had worked with older adults who have attended his classes over the past 13 years. At the time of this research, he was pursuing a Masters degree in Physical Activity for Health at the University of Edinburgh, funded through a Chevening scholarship.

5.2.4.7.2 Brief provided to the taster session yoga instructor. A brief on Study 3 and details of the taster session to be delivered was developed by the lead researcher and provided to the instructor (Appendix 35). The brief included:
(i) Background and brief summary of the objectives and status of the PhD project
(ii) Summary of the results of the systematic review to assess the effectiveness of yoga in improving physical function and HRQoL in healthy older adults (Study 1)
(iii) Objectives and findings of the qualitative study undertaken to understand perception of yoga in older adults (Study 2)

(iv) Objectives and summary of Study 3 including participant inclusion criteria and recruitment strategy

(v) Taster session components:

- The session was to be conducted at a gentle pace
- Props like chairs to be used
- Continuous movement between sitting/lying down and standing up, and complicated movements to be avoided
- The sessions to include some breathing and meditation, but not too much
- The duration of the yoga taster sessions to be approximately 30 minutes

(vi) Guidance for the instructor also included asking the participants at the beginning of the session if they had any injuries or health conditions, and providing posture modifications during the session. The instructor should also convey to the participants that they could choose their own pace, avoid postures they did not find comfortable, and not force themselves to perform the poses during the session.

(vii) Sample taster session structure: In addition to the sample taster structure and postures (Figure 25), a diagram of sample postures used in the study by Tew et al. (2017) was also provided. Specific postures that would be used in the taster session were highlighted. This was done to provide the instructor with illustrated examples of postures using chairs for support.

(viii) Information on the home-based sessions with the emphasis that postures in the home-based handout should be covered during the taster session.

(ix) The following documents were provided to the instructor for reference: KE event report (Appendix 25), leaflet (Figure 26), home-based handout (Figure 27), and an infographic on the physical activity guidelines for older adults (Department of Health, 2016).

The lead researcher also met with the instructor on one occasion and provided explanations for all the material included in the brief, answered questions and provided clarifications. The instructor was also informed that sample postures provided were a guide and he could integrate them with his own style. He could

modify and add new postures depending on the capability of the participants, as long as the intervention components were adhered to.

5.2.4.7.3 Understanding the instructor's experience of delivering the sessions. The instructor's experience of conducting the yoga taster was captured through a one-on-one interview (interview guide attached- Appendix 36). The interview guide addressed the following topics:

(i) Overall feedback on conducting the sessions.
(ii) Feedback on the brief and material made available to the instructor.
(iii) Comments on delivering the session.
(iv) Any additions or changes incorporated to the taster session during delivery, for example, new postures and modifications.
(v) Account of any adverse events during the session.
(vi) Suggestions for improvement.

All focus groups/interviews were conducted by the lead researcher. Data were collected between March and May 2018. All focus group sessions, and interviews were audio recorded. The recordings were transcribed by either the lead researcher or an external transcription agency.

5.2.5 Analysis

5.2.5.1 Analysis framework. The focus of Study 3 was to assess if the intervention components were perceived as appealing, appropriate and acceptable. Based on the definitions of these terms provided in Chapter 2, a framework was developed to evaluate these facets, where identified themes were classified as enhancing appeal, appropriateness and acceptability (Table 19).

Table 19

Classification of intervention components and feedback as appealing, appropriate and acceptable

Appealing	Appropriate	Acceptable
Enjoyment/likes and dislikes with respect to taster session, leaflet and home-based sessions	Occurrence of serious adverse events during taster and home-based sessions	Whether participants were able to do the taster and home-based sessions, and how difficult they found it
Creating a non-threatening environment and reducing feelings of embarrassment during taster session and conveyed in the leaflet	Injuries or discomfort during taster or home-based sessions	Whether apprehensions about movement between standing and sitting/lying down on the floor were reduced
Design, layout, language in the leaflet	Posture modifications provided by instructor during taster session	Comments on the breathing, meditative/spiritual aspects during the taster and home-based sessions
Pictures in leaflet and handout	Perceived benefits during taster and home-based sessions and from the leaflet	Whether the duration of taster and home-based sessions was acceptable
		Whether the structure and flow of taster and home-based sessions were acceptable
		Comments on class size and age of participants in the taster session
		Comments on information provided with respect to attire
		Comments on the instructor

	Whether the home-based handout containing postures already done in the taster with an instructor enhanced acceptability
	Clarity of leaflet and home-based handouts
	Use of props
	Whether the home-based handout was an acceptable mode of delivery compared to videos
	Comments on participating in future yoga sessions or continuing yoga

Other than evaluation of components and procuring suggestions to enhance appeal, appropriateness, and acceptability of the yoga programme, strategies to promote yoga in an older adult population were also noted.

5.2.5.2 Analysis of focus groups and phone interview transcripts. Within this a priori framework (Table 19), thematic analysis (Braun & Clarke, 2006) was used to analyse the focus group and interview data. Thematic analysis is a six-step process (Figure 29) starting with familiarisation with the data. The lead researcher read through the focus group and phone interview transcripts several times. For the next step, two researchers (DS, GB) independently conducted line-by-line coding of one focus group transcript to ensure consistency in coding and interpretation of the terms appealing, appropriate, and acceptable. A high level of agreement was found between the codes independently generated by the two researchers. The process of two or more researchers independently coding data and coming to an agreement over codes is typically carried out to ensure inter-rater reliability (Smith & McGannon, 2017). While this process is usually carried out to reduce bias and ensure results are replicable, recent studies have postulated that this method is not effective in enhancing the reliability of qualitative research (Smith & McGannon, 2017). Moreover, experts on qualitative research have cautioned against multiple coding of entire datasets due to time, effort and cost factors, but the value of multiple coding of some sections such as emergent coding frameworks has been highlighted (Barbour, 2001). Rather than focusing on inter-rater reliability, the supervisory team (CF, GB) acted as "critical friends" (Smith & McGannon, 2017, p. 113) during the analysis, offering interpretations and feedback on codes and themes. Smith & McGannon (2017) suggest that critical friends don't work toward agreement or consensus, but act as a sounding boards, encouraging reflection, and considering alternative explanations and interpretations of the data.

After multiple coding of the first transcript, initial codes were generated for all transcripts by the lead researcher and were transferred to a computer software package (Nvivo 11 for Windows). Step three involved searching for themes, and in

this phase the focus shifted from codes to broader themes. The process of combining codes to form overarching themes was carried out by the lead researcher using NVivo to manage the codes and thematic structure. The iterative process of reviewing and refining themes was undertaken in step four. In step five, the themes were defined and given a name that captured the essence of the theme. The final step involved writing the report in a coherent and logical manner providing data extracts to demonstrate the prevalence of the theme. Steps four, five and six were not linear, and themes were re-organised and re-named based on discussions and suggestions from the supervisory team.

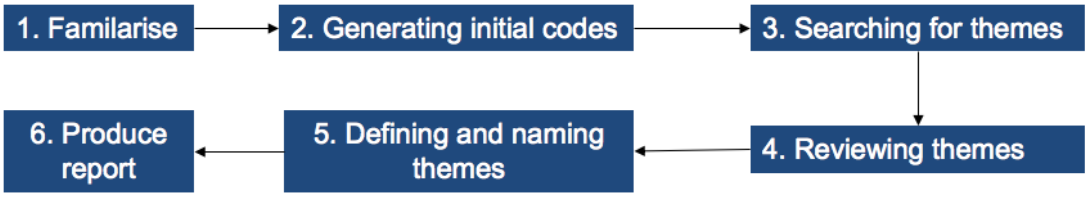


Figure 29. Six steps of Thematic analysis (Braun & Clarke, 2006)

5.2.5.3 Questionnaire data from taster session. The questionnaire data provided numerical assessment of enjoyment, levels of embarrassment, difficulty, and intention to join future yoga sessions. The responses to the Likert scale-based questions were represented diagrammatically, as percentages and average scores (mean ± standard deviation). The questionnaire also had open-ended questions which provided further qualitative data. Responses to open-ended questions from the questionnaire were coded in a manner similar to focus group and interview transcripts and integrated within the thematic analysis. The section below (section 5.2.5.4) provides details on integration of data.

5.2.5.4 Integration of data. Data from participants were collected through three sources: focus groups, questionnaires and telephone interviews. Though the phone interviews focused on the home-based session and handout, participants sometimes commented on the taster session. To allow integration of data from multiple sources into analysis, data triangulation was used. This process refers to the use of multiple methods, data sources, theories or investigators to develop a comprehensive understanding of phenomena (Carter, Bryant-Lukosius, DiCenso,

Blythe, & Neville, 2014; Halcomb & Andrew, 2005). Method triangulation incorporates multiple methods of data collection about the same phenomenon within a single study (Carter et al., 2014; Halcomb & Andrew, 2005). Merits of methodological triangulation include more comprehensive and insightful data, confirmation of findings, increased validity and enhanced understanding of the studied phenomenon (Bekhet & Zauszniewski, 2012). In this study, employing three different data collection methods added to the richness of the data collected, sometimes validating findings, and adding new dimensions. While transcripts were coded separately, relevant data from the three sources were brought together during analysis to provide a deep and complete understanding of each theme.

5.3 Results

Four yoga taster sessions, each followed by an evaluation session were conducted, with a total of 17 participants (Table 20). All members who attended the taster session also participated in the taster and leaflet evaluation. The mean age of participants was 74.7 ± 5.8 years (mean ± standard deviation), and 11 participants (65%) were female. Telephone interviews to collect data on the home-based activity were conducted with 16 participants, as one male participant could not be contacted.

Table 20

Number, mean age and sex of participants attending each taster and evaluation session

Taster and evaluation session	Total number of participants	Number of female participants	Mean age of participants (years) M(SD)
Session 1	6	3	77.2 (5.4)
Session 2	5	5	76.6 (5.3)
Session 3	3	1	68.7 (1.5)
Session 4	3	2	72.7 (6.8)
Total	**17**	**11**	**74.7 (5.8)**

M = Mean, SD = Standard deviation

5.3.1 Evaluation of Taster sessions

5.3.1.1 Appealing

5.3.1.1.1 Enjoyment

(i) Enjoyment- positive feedback. The first item on the questionnaire pertained to whether participants enjoyed the yoga taster session (Question 1: I enjoyed the yoga taster session), and the average score for this item was 4.3 ± 0.7. The majority of participants enjoyed the session with 7 (41%) choosing "strongly agree" and 8 (47%) choosing "agree" (Figure 30). None of the participants chose "disagree" or "strongly disagree". The fact that most participants enjoyed the session was apparent during the focus group discussions as well, with many expressing that they "enjoyed it thoroughly" and "loved it". The session being viewed as "good" or "great" was mentioned at all the four focus groups.

I found it very, yes, gentle, but very sort of happy feeling at the end of it all. (Female, 77 years)

Participants felt relaxed and stretched, and many of them noted that they felt good after the class. In the open-ended section of the questionnaire item on enjoyment, as well as in the focus groups, participants remarked that they found the session interesting and different from the usual weekly exercise classes that they participated in.

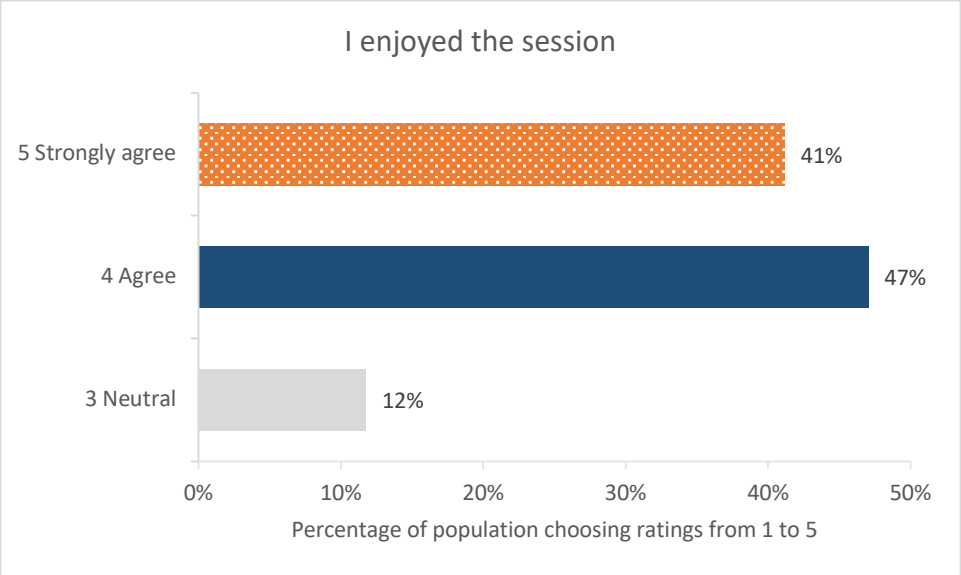


Figure 30. Response to questionnaire item on enjoyment

(ii) Enjoyment- negative feedback. Two participants did not enjoy the session. One female participant commented during the focus group and also mentioned in the questionnaire that she found the session too slow, and preferred other forms of exercise. Another reason she did not enjoy the session was because she thought the exercises were unusual. She also elaborated during the phone interview that she didn't feel that yoga suited her fitness needs, and preferred aerobics and circuit classes. Another participant did not communicate that she didn't enjoy the session during the focus group or the questionnaire, but revealed during the phone interview that she found yoga boring and that it was not her preferred style of exercise. Both participants felt that yoga was too static, and they preferred more active forms of exercise.

*5.3.1.1.2 Embarrassment***.** The average score for the item on feelings of embarrassment (Question 2: I felt embarrassed during the yoga taster session) in the questionnaire was 1.2 ± 0.6. "Strongly disagree" was chosen by 14 (82%) of the participants and 2 (12%) chose "Disagree" (Figure 31). No participant responded that they felt embarrassed during the taster session.

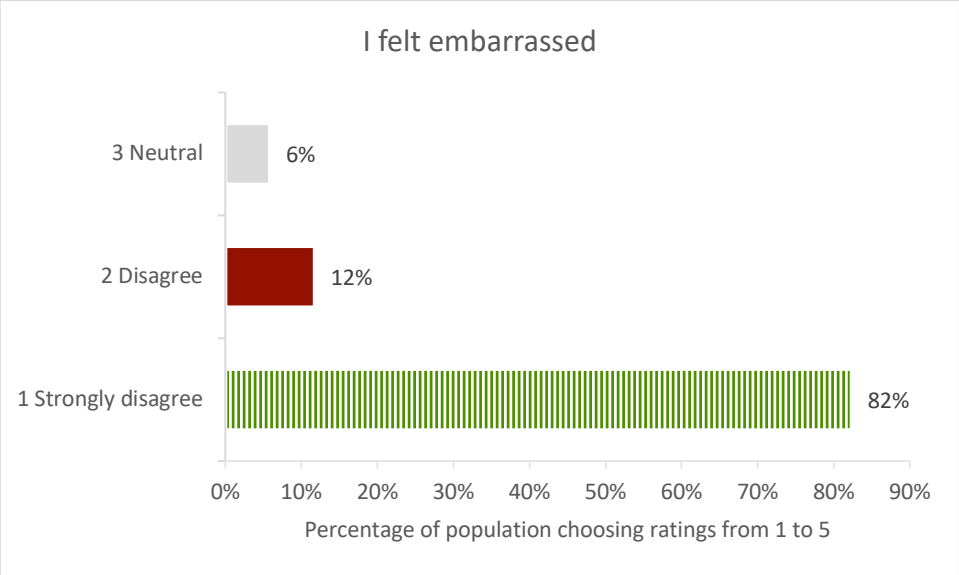


Figure 31. Response to questionnaire item on embarrassment

The reasons mentioned in the open-ended section of the questionnaire for not being embarrassed were that they felt comfortable and relaxed during the session,

that it was a small group of friendly people, all in the same boat, the session was well conducted, and that it was possible to do all the postures. The participants in the first two sessions knew each other, and this was one of the reasons cited for not feeling embarrassed. They also mentioned that they were made to feel that they could do the exercises, and that the instructor put them at ease. This was also mentioned during the focus group sessions as evidenced by this quote-

And I think the teacher made us feel comfortable that we didn't have to do anything that we felt was difficult, at all. (Female, 69 years)

5.3.1.2 Appropriate

5.3.1.2.1 Injuries or discomfort. No serious adverse incidents occurred, and as mentioned earlier, participants indicated that they felt good after the class, with no discomfort. However, some participants experienced pain during the session. Two female participants in the focus group session acknowledged that they experienced knee pain during the taster session. They both had a history of arthritis of the knee, and expressed that flexion was painful. Responses in the questionnaire from one of the participants with knee arthritis indicated that some of the exercises were difficult, and were uncomfortable or painful for the knees. However, during the focus group session, one participant said that while it was painful due to the arthritic knee, the session did not make it worse.

5.3.1.2.2 Posture modifications. The two participants mentioned above found postures that involved bending the knee "very tricky", and they also couldn't kneel. A third participant mentioned in the focus group, questionnaire and phone interview that he could not lie flat on the back, and hence could not try the floor exercises. He mentioned that he would have been able to do this if he had yoga blocks to support his neck and head. The instructor and participant had not realised at that time that the studio was equipped with blocks. One of the participants also mentioned that knee pain could have been avoided by modifying the postures. Although it was in the brief that posture modifications should be suggested to accommodate injuries and health conditions, this was not implemented. During the interview with the instructor, he

recommended that participants should avoid postures if they found it difficult, but did not mention modifications.

5.3.1.2.3 Benefits. During the focus groups, participants mentioned that they felt relaxed and stretched after the session. They felt that the postures worked on the entire body, and that they used muscles they weren't aware of, and hadn't used much.

Because you can feel it stretching your buttock muscles, your top of your thighs and especially the knee one where you pushing down, you could feel it. So, it's muscles that I don't think I've used much. (Female, 75 years)

After participating in the taster session, participants perceived that yoga would confer a number of benefits which they shared during the focus group. Benefits included improved balance, posture, mobility and movement (including benefits to shoulders), suppleness and flexibility. Yoga also helped with breathing properly and relaxation, which was seen as a major benefit. Participants felt that yoga would be good as an add-on to their current exercise programme, or would be an alternative if they could not make it to their exercise class. Two participants mentioned that if they were not able to continue their current physical activities, they might take up yoga.

Benefits from attending the taster session were discussed by participants during the phone interview as well. They mentioned that holding the postures had a positive effect on the body. Benefit to shoulders, feeling stretched, and working the core muscles were also mentioned.

I was clearly using abdominal or core muscles that I haven't been using before, or as much. (Male, 74 years)

5.3.1.3 Acceptable

5.3.1.3.1 Difficulty and challenge. The average score for the item "Question 3: I found the session difficult" was 2.12 ± 1.05. A majority of the participants (11

(65%)) did not find the session difficult, and only a few participants (2 (12%)) agreed that they found it difficult (Figure 32).

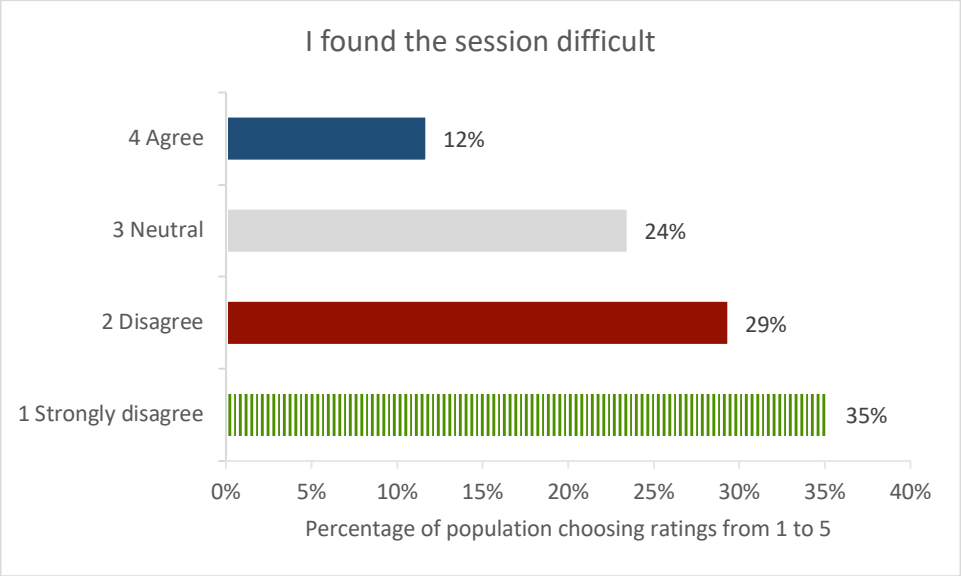


Figure 32. Response to questionnaire item on difficulty

During the focus group discussions, participants described the taster session as gentle. This was also reflected in the questionnaire where they said that they could complete the session with ease. Though the exercises were different and unfamiliar, they were manageable and not difficult. Participants remarked during the focus group and in the questionnaire, that they thought it would be more difficult, and were surprised that they could do most of it. They also mentioned during the focus group that the session was suitable for older adults, and easy to do as you age. It was geared for them, and within their capability, which was reflected in their questionnaire answers as well. The response given by one participant to an item in the questionnaire on future participation in yoga sessions was “if it is like this”, reiterating that he found this yoga session suitable.

However, some participants mentioned in the focus group and questionnaire that not everything was easy to do, and some of the session/class content was difficult and taxing. Age and unusual exercises were mentioned in the questionnaire as reasons for finding the session difficult, and some of the balance exercises were

found to be challenging. Though they found it challenging, they also found that yoga exercised all parts of the body. In the home-based interviews, many said that during the taster session they had used abdominal and other muscles which don't usually get used, and had muscle aches after the session.

I do Aquafit and I do the circuit classes. And this is really quite different and it's a little more challenging, because I think holding the stretches really makes you..works your body. (Female, 78 years)

*5.3.1.3.2 Movement between standing and sitting/lying down on the floor***.** The participants thought that grouping of postures to minimise movement between getting down and up worked well. They felt that they would be quite tense if there was a lot of up and down movement. Knowing that one didn't have to get up and down each time made it more relaxing for them. They felt that one should only need to get up from a lying down position when the class came to an end.

In the first session, the instructor had asked participants to put their hands over their heart as they were getting up from the floor. The participants mentioned during the focus group session that they found this difficult, and this feedback was passed on to the instructor who amended this instruction for the remaining sessions. In another session, participants mentioned that the technique for getting up from the floor was not explained, and that it would be helpful if the instructor guided them through this, as older people may not be used to the movement. This was noted and added to the guidance for instructors.

5.3.1.3.3 Breathing, relaxation, meditative and spiritual content. Participants enjoyed the breathing and relaxation aspect, and found it helpful and valuable. They felt it was a lovely way to end the session and thought it was very relaxing. Some felt that it was difficult to do the abdominal breathing the right way. During the corpse pose, participants were asked to lie down with their palms opened out facing the ceiling. They mentioned that this was less relaxing, and they would prefer palms down or sideways. Participants felt the duration of the breathing component was just right.

Participants also said that they had anticipated having to lie down and perform unusual gestures like sticking their tongues out, and were surprised that it was more about breathing and relaxation. They appreciated that the session was more practical.

R: ...So we didn't have to say 'om' or anything, once, did we? (Laughter) So yeah, I am pleased with it."
I: And do you think the fact that it didn't have a lot of, you know, spiritual content, did that make you feel more comfortable

R: Yes, so just more practical, wasn't it?
(Female, 81 years)

(i) Breathing during postures. Participants found that breathing during postures was confusing, and sometimes they tended to hold the breath in. Two participants mentioned that yoga breathing in postures was contradictory to the breathing they were taught as physiotherapists. Physiotherapists are taught to inhale on effort and exhale on relaxation, as inspiration is an active process and expiration is relaxation. The lead researcher then explained that with yoga, you inhale when you open out the body and exhale when you contract. After this explanation, participants felt that they could reconcile the principles of yogic and physio breathing, and felt that the contradiction was reduced.

*5.3.1.3.4 Duration, structure and flow***.** Most participants were happy with the duration of the taster session. They understood that a normal session would be of a longer duration. Some felt that they would have liked the taster to be a little longer, although they appreciated that the idea of a taster is that it's not too long and onerous. Participants thought that the structure of the session was good, and progressed logically from one exercise to the next.

5.3.1.3.5 Class size. Participants appreciated the advantages of a smaller class. In one of the sessions participants discussed a preference for more space, and could have relaxed even more if they were not infringing on someone else's space.

The studio was fairly large and the session had only three participants, but the arrangement of the mats could have led to restricted personal space.

*5.3.1.3.6 Attend with people of the same age group***.** Some participants from one focus group felt that it was important to attend classes with people of the same age. They felt they might be stiff and awkward in contrast to the young and thin participants at yoga classes, who would make them feel demoralised. It was felt that in a group of people with similar ages, they wouldn't feel foolish if they were unable to do some of the postures, and they could try it again later. They also felt that the instructor would be more careful with a class of older people.

And the teacher is also a bit more careful about, you know, if you can't do anything, you don't feel like an idiot, you feel it's okay not to… (Female, 69)

5.3.1.3.7 Balance between having variety and introducing too many new exercises. Participants liked that they covered a variety of different exercises during the taster session, and were not doing the same exercise for extended periods of time, which kept it interesting.

There were however mixed views on whether there were too many exercises for an introductory class. Some felt it was appropriate as the session was geared for older people, and that it was natural for many new exercises to be introduced during a taster session. In contrast, one participant felt that by the time he had got his head around one exercise, they had gone on to the next. Introducing a limited number of new postures each week was suggested.

*5.3.1.3.8 Attire***.** During recruitment, the lead researcher was able to directly contact some participants and requested them to wear clothing that they were comfortable exercising in. However, it was not possible to contact all participants. Therefore, this information was not provided to participants recruited via the leisure centre, who regretted not having the opportunity to change into more comfortable, loose clothing for the sessions. It was felt that it would be good to provide instructions on appropriate clothing and shoes for the session. These comments were made by the taster session participants who were not informed about attire. Most

participants wore their shoes during the session. However, one participant wore his socks during the session and said that he felt unstable in his socks and should have worn gym shoes or just gone bare feet.

5.3.1.3.9 Instructor.

i) Positive comments on the instructor. Participants thought the instructor was good, and had a relaxed manner. They felt that he recognized that older adults may have aches and pains, may have issues such as shoulder trouble, and may not move very well. They appreciated that he asked if they were feeling alright or if they needed help. They also said that the instructor walked around and was good at adjusting and correcting postures. They were doubtful whether this would be possible in a larger class. Participants found it inspiring that he moved very beautifully. But through the awe there was also a hint of dejection and irony among some participants, as they said watching him was depressing.

ii) Provided explanation. The participants found it useful and interesting that the instructor provided clear explanation on the part of the body that was being worked on. They also appreciated other details provided during the session such as tips on how to balance, and information about the breathing.

iii) Demonstrating. The instructor physically demonstrated the poses, and participants found this helpful. They also liked that he demonstrated using different planes and angles, straight ahead, and then sideways, so participants could see what he was doing. The participants mentioned that the instructor demonstrated what they should do in the current session, and also showed them what they were aiming for. They felt it was nice to know what the eventual aim of the exercises was. This aspect was not an intervention component nor mentioned in the brief to the instructor, but was a part of the instructor's style of teaching.

iv) Gender of instructor. Both male and female participants felt that the gender of the instructor would not make any difference. Having a female instructor was not considered an issue.

v) Some criticisms. In the first session, participants got the impression that the instructor was working outside his comfort zone. They noticed that he kept referring to a piece of paper, which affected the flow. The researcher discussed this with the instructor, re-emphasising that the sample session was a guide, encouraging him to bring his own style to the session while keeping the principles of the taster session in mind. This point was not raised by participants in the subsequent sessions.

Participants in one of the focus groups felt that it was important for the instructor to "mirror the audience" while demonstrating. They cited the example of another class that they attended where the instructor demonstrated the exercise on the right side when the participants were required to work on the left side. The current instructor did not do this, due to which there was some confusion, and participants suggested that mirroring the class would be helpful.

A final comment was that since the instructor was a non-native English speaker, the participants sometimes struggled to understand him. They also felt that he did not seem "au fait with the nomenclature" and was often looking for an appropriate word. They mentioned that clarity and confidence was important in an instructor. These comments were only made by the first group, and could be due to the fact that it was the very first session. With experience, the instructor seemed to grow more comfortable and confident with conducting the sessions. This was reflected in the fact that there were no other comments related to nomenclature or language from subsequent groups.

5.3.2 Evaluation of leaflet

5.3.2.1 Appealing

5.3.2.1.1 Content. Overall, the leaflet received very positive feedback with comments like "very nicely put together", "not too patronising or over simplified", "seems very good".

It was felt that the leaflet was clear and provided useful information and explanation. There was enough information without it being overloaded. Participants appreciated the following aspects-

(i) Information on benefits such as balance and performing day to day tasks. Participants were especially interested in the mention of improvements to brain function and memory.

(ii) Participants related to the social aspect of exercise, and felt that it was good that meeting people was featured in the leaflet. They also found the mention of tea, coffee and cake appealing.

5.3.2.1.2 Creating a non-threatening environment and reducing feeling of embarrassment. The leaflet had a quote (from Study 2) that said that you could do yoga to whatever extent that suited you, and participants felt this was pertinent.
The great thing about yoga is that you only do it to whatever extent is suitable for you. You know, you can (Yes) do it, come in at whatever level you are able to do. (Female, 82 years)

Participants appreciated the line from the leaflet "Yoga is for everyone, try it", and felt it was good that the enjoyment factor was mentioned.

*5.3.2.1.3 Comments on the design layout and colours***.** The participants commented that the leaflet was colourful and eye catching and they could read the font size comfortably. They criticised other pamphlets that had red or green backgrounds which made it difficult to read. With respect to the size of the leaflet, they felt that it was fine for a notice board, but would not fit into a handbag, and may be bulky to take away. A foldable booklet was suggested as an alternative.

*5.3.2.1.4 Comments on language and wording***.** Participants observed that the leaflet used a variety of appropriate and positive words like "have more energy" or "enjoy better sleep". The language used was simple with no jargon.

5.3.2.1.5 Comments on pictures. Participants felt that good, realistic pictures were used in the leaflet. It featured people they could identify with, and they were not "frightened by posh yoga clothes". They also found that the pictures were reassuring and not too challenging, as the people were not doing contortions on the floor. They found having a chair in the pictures reassuring.

One participant felt that the picture at the bottom of the leaflet (person with arms extended) did not seem challenging enough. On the other hand, another participant felt that the picture on the top looked slightly difficult, and he would be dissuaded if it was reflective of the whole session. Participants agreed that finding pictures with the right balance was tough-

That's right. It's just difficult, because you don't want to frighten people off either with too much exercise, or not enough. So you have to find the right balance and that's bound to be difficult. (Female, 70 years)

5.3.2.1.6 Additional suggestions. It was felt that including pictures with both men and women would be better, as having some men in the pictures would encourage male participation. It was important to emphasise in the leaflet that yoga was for both genders, as men may feel that yoga was a female dominated activity. There was a suggestion that prevention of falls should be stated as a benefit of yoga.

5.3.3 Evaluation of home-based sessions and handout. All participants but one were able to do the exercises at home. One participant mentioned during the phone interview that he did not do the exercises due to a recently diagnosed health condition.

5.3.3.1 Appealing

5.3.3.1.1 Enjoyed doing the sessions. Most participants had positive feedback on the home-based sessions, and expressed that they enjoyed doing the exercises at home.

I quite enjoyed that actually. I don't very often enjoy doing it in front of a video or something like that. But I quite enjoyed doing these. (Female, 77 years)

5.3.3.2 Appropriate

5.3.3.2.1 Injuries or discomfort. No serious adverse events were reported. Most participants experienced no injuries or discomfort during the home-based practice. One participant had an arthritic knee and experienced some pain, specifically in the warrior pose. One participant felt some discomfort in the hamstring stretch. He explained that he felt the stretch in his hamstrings but couldn't straighten the leg. This could be attributed to limited hamstring flexibility.

5.3.3.2.2 Benefits. Participants felt that the home-based sessions helped with limbering or loosening up.

..at my age you tend to stiffen up, you know. And, so anything that you can do to preclude that is good. (Female, 82 years)

Another benefit was that the exercises helped them relax. They felt that the exercises were beneficial for their stomach muscles. Better posture, and improved strength and balance were also mentioned.

5.3.3.3 Acceptable

5.3.3.3.1 Ease of doing the exercises. Participants found the home-based sessions easy to do by themselves. Some participants said that initially, they had to keep checking the handout to ensure that they were doing the postures properly. They did however feel that with time, it flowed better and they got more adept at doing the postures. After doing it a couple of times they could do them without referring to the handout. Some participants mentioned that they found it difficult to read the handout and do the exercises in parallel.

Most participants found it helpful that they had done the exercises from the handout previously in the taster session under the supervision of an instructor. They felt the instructor provided a background and more detailed explanations. They were shown what was involved and how to do the exercises correctly.

I think so – I think you need somebody to show you roughly speaking what's involved; and if need be, come around and correct if you are doing wrong things. I think that's important, that you have been shown what the exercises are. (Male, 74 years)

One participant was confused about whether he had done the same postures during the taster. Another participant felt that they had just done one short session that covered a lot of different things, and did not feel that she had become familiar with the routine.

5.3.3.3.2 Not demanding enough. One participant only completed one home-based session and felt that they were a bit easy and not demanding enough. She was aiming to achieve 10,000 steps a day, and preferred exercises like walking uphill. She mentioned that she was younger that the rest of the participants in the taster group, due to which she might have found the exercises too simple.

5.3.3.3.3 Comments on specific poses and breathing.

(i) Pose 1- hamstring stretch. The participants liked this pose, and thought it was helpful. One participant mentioned that it helped with her arthritic knee- *Certainly the first one because I have a lot of arthritis and my knees get stiff and I found doing the stretch actually helped when they felt a bit sore. (Female, 81 years)*

Some participants felt that the height of the chair was critical for this pose, and one participant had to change to a lower chair to suit her (shorter) height.

(ii) Pose 2- warrior. The participants found the instructions and picture for this pose confusing. They were not sure which way to face and where to put the chair. They were unable to tell from the picture if they should have their legs apart sideways or facing the front, and could not understand which leg was bent.

(iii) Pose 3- standing balance. Participants recognized that balance was important at their age and hence found this pose beneficial. One participant found

that she had to work hard in the posture, and the muscles of the leg that was lifted got quite fatigued and started to wobble. Other participants felt that they did not find it strenuous, and agreed that taking their hands off the chair could make the posture more challenging.

(iv) Breathing. The feedback on the breathing exercise was mixed. Some participants found it boring. They did not find it very helpful, did not think it would be beneficial, and questioned why it was included. Instead, they would have preferred more of the physical postures. Others thought it was good, and that it helped oxygenate the body. They felt that it could help with asthma, as well as exercise the stomach muscles. Some participants also found it difficult, as the way they had been breathing (stomach in when you inhale, and out when you exhale) is different from the abdominal breathing (stomach out when you inhale, and in when you exhale), and they had to concentrate while doing it. One participant felt that she was able to do this better if she was lying down.

Apart from the breathing exercise, participants found breathing during the postures complicated as well. They often forgot to breathe as prescribed, and had to keep reminding themselves, and also found that they were holding their breath. One participant wondered how important it was to breathe as described during the postures.

5.3.3.3.4 Frequency and duration. Participants were advised to do the postures at home on at least two days of the week. One participant tried it only once, as she found the postures too easy. Another participant said that she had done three session a day on all days since the taster session. For the others, the frequency of performing the home-based sessions ranged from twice to every day of the week.

The estimated time to complete the session as provided on the handout was 5-10 minutes. The range reported by participants was 5-20 minutes, with seven participants reporting 10-15 minutes, four reporting 5–10 minutes, and two reporting 15–20 minutes. Participants were comfortable with the time they took to complete

the session, and could finish the session without getting exhausted. One participant felt it could have been extended, either by holding the poses for longer or doing one more repetition of all the postures. Participants were also comfortable with the length of the session in terms of fitting it into their daily routine.

Because it was not too long, so it was fine, it was absolutely fine. (Female, 75)

5.3.3.3.5 Structure and flow. Participants had some questions on whether each pose should be performed 2-3 times, or if the entire routine was to be repeated 2-3 times. There were also some questions on when to do the breathing, and whether it was to be done along with the exercises. Some of them did it separately and not with the exercises. One person preferred to do the breathing at the beginning rather than at the end. One participant integrated the postures from the handout into his morning exercise routine.

5.3.3.3.6 Clarity. Participants found the handout clear and the instructions easy to follow. The pictures enhanced ease of understanding directions, and participants described them as helpful and clear. The one exception was the warrior pose. As mentioned earlier, a majority of participants found the pictures and directions for this pose confusing.

5.3.3.3.7 Props. It was seen as an advantage that no special equipment was required for the exercises, all that was needed was a chair which was readily available. Participants found it helpful to use a chair during the sessions.
I mean, you sensibly suggested there's a chair there. So if one's stance isn't as good as it might be, there's always a chair to help, isn't it? (Female, 81 years)

5.3.3.3.8 Home-based vs class-based. Participants felt that it was difficult to be regular with home-based practice and had a preference for class-based sessions. This was because they felt more motivated, disciplined and focused in a class. They felt more confident in a class-based session as it was conducted by a professional. They predicted that their initial enthusiasm with home-based sessions would soon

wane. One participant mentioned that there was more incentive to go to a class with friends.

The fact that the lead researcher would contact them by phone prompted the participants to make more of an effort with home practice, and following up was one suggested strategy to improve regularity with home-practice.

5.3.3.3.9 Video vs handout. Eight participants expressed their preference for a handout as a mode to access home-based exercises, while four described the advantages of a video. Two participants saw the advantages of both mediums. One participant was against using videos, with no comments about preferences for a handout. Those in favour of the handout said that they liked it and it suited them better than a video. They found the handout simple, quick and easy to use as it was explained well, so they did not feel the need for a video. As opposed to a video, no equipment or setting up was required. They felt they could use a handout anywhere, while using a video was a disadvantage if there was not enough space in the room. Moreover, a few of the participants were against technology altogether. While some were comfortable accessing the video on the internet, others felt it was too much of a task, and there was some concern that many older adults may not be comfortable accessing the internet.

Those who preferred a video thought it would be more enjoyable and interesting than using a leaflet. One participant mentioned getting impatient with the handout, and some participants felt that videos could provide the motivation to do the postures at home. Another participant struggled to read a handout and do the exercises at the same time. In addition, they couldn't recall the postures on the handout and had to keep referring to it often. In contrast, some participants felt that it would be easier to watch a video and do the exercises at the same time. They also felt that videos give a better picture of what you're meant to do than handouts.

5.3.3.4 Purpose. Participants felt that the handouts could be helpful for people who don't exercise regularly, as it would get them into the habit of doing something. They felt that if people were considering initiating exercise, the handout would be there right in front of them. The handout would be useful to people who could not make it to class, to keep things going between classes, or if classes were suspended. Those who had been attending regular yoga classes might still not remember the postures, and handouts could serve as a reminder. They would also ensure that one did not cheat or miss out exercises. However, it was felt that handouts could not replace a class, and that these handouts needed to be developed further, as just four exercises were very minimal. Finally, the handouts could capture the interest of those who had never tried yoga, and might encourage them to attend a class. Participants felt that since they now know more about yoga, it would similarly give others an idea of what to expect in a yoga class.

Yes, I am thinking that people like myself who have never tried yoga. I was always thinking – oh, I wonder if I could try that. But trying to walk into the class and not knowing. If I get the handouts, at least we are knowing - an idea of the type of the exercises and that could encourage them to go into a yoga class. (Female, 70 years)

5.3.3.5 Additional feedback

i) A few participants felt that having a series of handouts with different postures, or more exercises on the other side of the card would be helpful, as they would eventually get bored of these four exercises.

ii) During the taster session, the instructor should highlight the postures included in the handout and stress that these would be a part of the home practice. The instructor should also ensure that these postures were covered during the session.

iii) One participant wanted to try the floor-based exercises at home, and the researcher explained that the handout had simpler chair-based postures, and perhaps more complicated postures could be introduced at a later stage.

iv) Two participants questioned whether the postures qualified as yoga.

I think a lot of people will be surprised how this comes under the banner of yoga. People have a strange impression, including me, about what yoga is really like, or what it can be. Yeah. So many varieties or whatever. (Male, 69 years)

The researcher explained that though the postures were modified, they were indeed yoga, with movement co-ordinated with breathing.

v) One participant mentioned that because she was doing the home-based yoga postures, she need not push herself to go for a walk. The instructor should emphasise that yoga does not replace aerobic exercise.

vi) A participant questioned whether the postures were just haphazard choices or if they were connected to each other. The lead researcher explained that the three postures were specifically chosen to address flexibility (Pose 1), strength (Pose 2), and balance (Pose 3).

vii) One participant did one of the home-based sessions in normal clothes, and felt that were too tight. She felt that remembering to wear loose clothes to do the exercises may be tricky.

viii) One participant wondered whether it was acceptable to do the postures while doing other activities such as watching television or listening to the radio, or should he focus completely on yoga. The researcher advised that any activity is beneficial, and the participant felt that he could see himself performing the postures while watching the news and other activities.

ix) A small number of participants said that if they were given a handout with postures they have done in class, they are likely to practice it at home regularly. One participant said that she would do the hamstring stretch on her own.

5.3.4 Addressing the barrier of lack of information

Lack of information on yoga was identified in Study 2 as a barrier to participation, and in the current study, the taster session and leaflet were evaluated as strategies to address these barriers.

5.3.4.1 Taster session as a mode to address the barrier of lack of information.

Participants felt that the taster session gave them the opportunity to experience yoga without paying a lot of money. The half hour session gave them a

good idea of what it entails and they could gauge whether they would like to continue or not. Some participants felt the session had inspired them to explore yoga further, and that they might join a yoga class since they enjoyed it. They also thought that people would be convinced by a taster session, and felt that it was a good idea to offer such sessions to those who had never done yoga. As mentioned before, the session helped change some participants' negative perceptions of yoga, and they were surprised that there were no odd gestures such as sticking the tongue out or chanting. They had also anticipated finding yoga difficult, which was a barrier to participation identified in Study 2. The taster session helped alter this perception, and participants were surprised that they could do almost all of the postures.

5.3.4.2 Leaflet as a mode to address the barrier of lack of information. All participants felt that the leaflet gave them new insights into yoga, especially about its benefits. As evidenced by the following quote, they felt that the leaflet gave them an understanding of yoga-

R1: Because I've thought about—I've thought about yoga before. And the thing that's kind of put me off is because I didn't really know anything about it. (Female, 70 years)
R2: Likewise, yeah. (Male, 67 years)
R3: Yeah. (Male, 69 years)
R1: So, if I was looking at that… Looking at that, I know exactly now what it's about. (Female, 70 years)

However, it was felt that the leaflet did not provide certain crucial information. Almost all participants observed that the leaflet did not have any information on where they could do yoga. They felt that it would be useful to have information on the back of the leaflet on places offering yoga, contact details, website, whether it was a drop-in class or if you had to sign up. Participants also felt that there were many different types of yoga, and were confused about which styles were suitable for older adults. They would find information on the types of yoga suitable for older adults very useful. One focus group participant felt that the leaflet did not explain how the class was suitable for older adults. Another participant argued that since the age was over 65years, it gave you an idea of what to expect.

However, it was felt that information on what was done differently compared to normal yoga, to make the class suitable for those over 65 would be useful.

5.3.4.3 Home-based handouts addressing the barrier of lack of information. Although it was not evaluated as a mechanism of providing more information about yoga, two participants felt that the home-based handout would give people with no information about yoga an idea of what to expect.

..I would never have attempted to go into a yoga class. But if we got the handouts and were able to try at home and it gave you the confidence because you didn't feel as if you were the new person, because you know you had an idea of something… (Female,70)

5.3.5 Yoga opportunities

5.3.5.1 Participating in future yoga sessions. The average score for the item in the questionnaire on whether participants were likely to participate in future yoga sessions (Question 4: I am likely to participate in yoga sessions in the future) was 3.71 ± 0.77. While 5 (29%) participants were neutral, 9 (53%) of the participants agreed, and 2 (12%) strongly agreed that they were likely to participate in future yoga sessions (Figure 33). From their responses on the open-ended section, it seemed that they were enthusiastic about continuing with yoga, but would struggle to fit it in given other commitments. Since these participants were recruited from exercise classes, one reason given was they already do other forms of exercise.

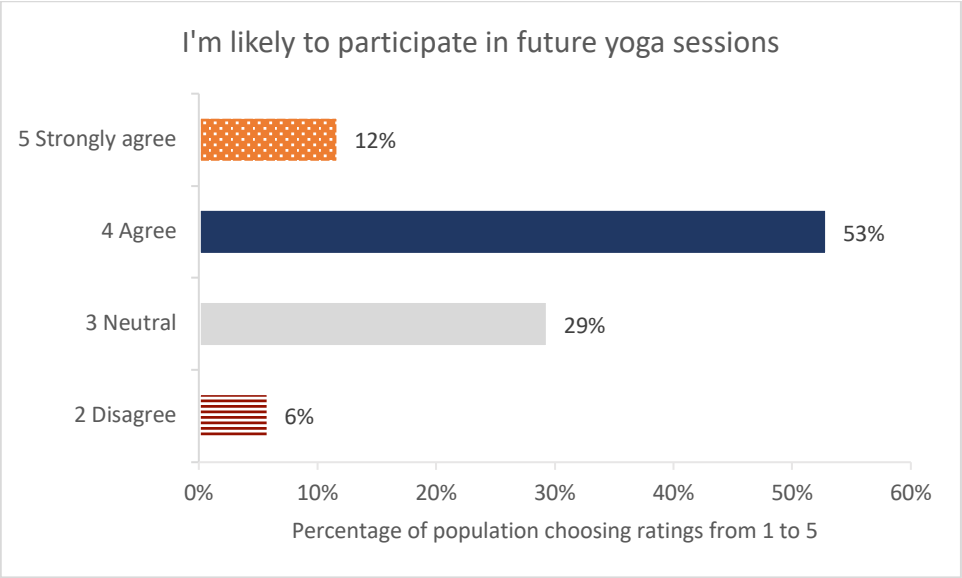


Figure 33. Response to questionnaire item on participating in future yoga sessions

Many participants expressed during the focus group that they would like to take up yoga. This was in line with the questionnaire data, although their inclination to take up yoga may be restricted by their current physical activity and other commitments. They also felt that people should be offered the opportunity to join a yoga class. This was reiterated during the phone interviews as well-

No, I think as I said, I have said to you before, if people are convinced, and I think people may well be by the interview with you, and the lesson on the practice. And to really make it complete, they would need to be offered fairly soon an opportunity to actually take it up. (Female, 81 years)

Participants expressed that they would like to take up a short summer course consisting of about 6 yoga sessions, similar to the taster. They may find it difficult to attend a regular yoga class, but would be able to do a course, learn the basics and then continue practicing at home.

5.3.5.2 Did the leaflet motivate participants to try yoga? Most participants concurred that the leaflet would motivate those who hadn't previously done yoga to give it a try. They felt that it was a good starting point to get people curious, and encourage them to participate.

Yeah. Is this just a general leaflet to get people (yeah) interested in the big world of yoga, then it's fine, it does its job. (Male, 69)

A summary of whether the taster session, home-based practice and leaflet were appealing, appropriate and acceptable to older adults is presented in Appendix 37.

5.3.6 Understanding the instructor's perspective of delivering the session. In the one-on-one interview with the instructor, key elements of delivering a yoga session for older adults were discussed.

5.3.6.1 Working with an older adult population. The instructor noted that it was not easy to teach an older adult population, and he needed to be more careful with this group due to age, health conditions and inexperience with yoga.

5.3.6.2 Comment on the brief given to the instructor. The instructor felt that the aims and principles of the programme were clear, and easy to understand from the brief provided. In the brief (Appendix 35), the structure of the session (including postures) were provided in written format and supplemented by a diagram with sample postures from a published yoga RCT for older participants conducted in the UK (Tew et al., 2017). The instructor struggled with combining the written instructions and pictures, and felt that they were not well connected. He had to create a separate drawing combining the text and pictures. He suggested that for future sessions, clearer instructions that combine text and pictures would be helpful to the instructor.

5.3.6.3 Creating a non-threatening environment. The instructor felt that asking the class how they were feeling, and about any health conditions worked well, and created a connection between him and the group. Sometimes the group would discuss and provide some feedback. Although they might not be forthcoming about health conditions in the beginning of the session when prompted, they may open up during the course of the session. There was a discussion between the instructor and

lead researcher at this point, emphasising the importance of creating an environment where participants felt comfortable about sharing health issues, if not at the beginning, at some point during the session.

One of the components in the brief to the instructor included conveying to participants that they should not force themselves, and should only do as much as they could. The instructor adopted this non-violent approach throughout the session, and felt that it was important to remind them before or during each exercise, rather than just at the beginning. This would deter them from doing movements that might be too difficult, and pushing too hard too soon.

5.3.6.4 Additions to class content. The instructor introduced some new additional material that was not a part of the sample taster session content. Sukshma Vyayama and Sthula Vyayama exercises were added to the warm up component of the taster sessions. The instructor explained that these are a short sequence of standing and sitting (using chairs) positions, which could be used as warm up exercises for joints, muscles and tendons. They include repetitive movements for the shoulders, elbows, wrists, knees and other joints. He felt that these exercises would be suitable for the older population. Participants appreciated these postures as they were dynamic and produced heat and energy, and created an awakened state in the beginning of the class.

5.3.6.5 Comments on the corpse pose. The instructor recommended that some breathing should be done after the corpse pose at the end of the class. In his experience as an instructor, he found that older adults may fall asleep during this pose, and may be too relaxed after the corpse pose. He considered the corpse pose to be meditative, and one is not meant to fall asleep during this time. He prescribed including some breathing at the end as it would provide some activation after the corpse pose. He also had recommendations on the duration of the corpse pose. He felt that the duration was too short in the taster session (2 to 3 minutes), and would be around 15 minutes in a normal class. However, relaxing for too long in the corpse

pose could diminish the effects of yoga, and if a yoga session was meant to be more energetic, a shorter corpse pose duration may be advised.

5.3.6.6 Partner work. The instructor suggested partner stretches where two participants work with each other during postures. Working in pairs could be safer as they use each other's help. It also had psychological benefits from social interaction, and feeling that they were all together in the same boat. After some discussions between the instructor and lead researcher it was agreed that culturally, participants in the UK may not be very comfortable with partner work in the very first class, or at the beginning of a yoga course. However, in a longer yoga programme, partner work could be introduced at a later stage, when people were more familiar with each other.

5.3.6.7 Demonstrating advanced versions of postures. The instructor demonstrated two versions of postures- a simple version to be performed during the taster, and the most advanced and final version. He felt that showing the advanced version would help them understand the movement. This was done to give them a better idea of the posture, and was not to be executed immediately. Participants appreciated this aspect, but also seemed a bit daunted by the advanced postures.

5.3.6.8 Props and room. The instructor felt that the props provided (chair, mats, blocks) were adequate. He recommended the use of more stable chairs to prevent accidents. He advised that yoga studios should not be cold, and rooms should be warm enough (but not too hot) to open up the body. He judged that the temperature in the studios where the sessions were conducted was at an optimal level.

5.3.6.9 Adverse events. The instructor did not notice any injuries during the session. He observed that people found it a bit uncomfortable at times, but felt that this was because they were performing movements they had not done before. He felt that some discomfort was to be expected as any exercise would involve effort and the use of muscles.

5.3.6.10 Tips for handling different capabilities. One suggestion from the instructor for handling a group with different capabilities was to ask them to completely avoid postures they found difficult, and focus on breathing instead. He also felt that they should be advised not to worry about being able to do postures, and avoid competitiveness. While one instructor was sufficient for smaller classes such as the taster session, for bigger classes, the instructor recommended 2-3 assistants. One person would demonstrate while others walked around and corrected postures. Another suggestion was to have a multi-level approach to demonstrating postures. He suggested starting with the simplest pose, and then progressing to more advanced variations. He felt that for older adults the range for each pose is limited with just one or two options, due to restricted mobility.

5.4 Discussion

This study evaluated whether the yoga intervention components were perceived as appealing, appropriate and acceptable among older adult participants. Feedback to further refine the yoga intervention, and strategies to encourage yoga participation in older adults were also compiled. Instructor feedback on conducting the taster sessions was procured. To avoid repetition, the intervention components are not be discussed in the current chapter in the context of other published literature, as this exercise has been undertaken in the next chapter (Chapter 6).

5.4.1 Taster session. On the whole, participants found the taster session appealing, except for two participants who found yoga too static, and preferred other forms of exercise. In Study 2, an identified barrier to participation was that older adults felt that they would be embarrassed if they were not able to do some of the postures in the class. To combat this, a key component of the taster session was that the instructor should strive to create a comfortable, non-threatening environment. It was important to convey to participants that they could choose their own pace, not force themselves and avoid anything they found uncomfortable. The brief to the instructor included these components and the lead researcher emphasised these aspects during her meeting with the instructor. From the feedback it appears that the

participants appreciated this aspect, and a comfortable and conducive environment was successfully created.

The sessions were found to be appropriate with many perceived benefits and no serious adverse events. Participants with arthritis found the sessions painful, especially on the knee. While the brief for instructors suggested posture modifications, more detail and training on appropriate modifications for key problem areas and health conditions (example: arthritic knees, difficulties in reclining (section 4.3.1.2.2)) in older adults is required. Training instructors on appropriate posture modifications will make the sessions safer and more appropriate for older adults.

The programme addressed certain barriers identified in Study 2 such as apprehensions around finding yoga difficult, continuously getting down and up from the floor, and having heavy spiritual content. In this regard, the programme could be described as acceptable. While most people found the breathing and relaxation aspects enjoyable and useful with optimal spiritual content, breathing during postures was found to be confusing. A breathing strategy suggested by the researcher during the focus group discussions seemed to ameliorate the confusion. A rule of thumb breathing strategy such as this may help make breathing during postures less confusing and more instinctive. Instructors could also convey to participants that it may take time and practice to get comfortable with coordinating breath and movement. Participants should be advised not to get discouraged if they experienced initial difficulties with breathing during postures.

Some participants did not receive information on what to wear to the session. In retrospect, adequate information on suitable attire for the session should have been provided to all participants. Moreover, instructors should warn participants that wearing only socks during the session would increase the risk of slipping, and provide clear instructions on keeping shoes on or performing the postures barefoot. Yoga is traditionally performed barefoot. However, Bonura (2011) suggested that older adults should be allowed to keep their shoes and socks on while practicing yoga in case they have foot conditions, balance issues or experience discomfort (physical or psychological) with being barefoot. While this

is a valid recommendation, it could be modified based on results from this chapter, adding a cautionary note about increased risk of slipping with socks.

5.4.2 Leaflet. The participants liked the leaflet and found it useful. They felt that it would motivate people who did not know a lot about yoga to try it. Many aspects were appreciated such as the colours, wording, as well as information on the benefits of yoga, and mentioning the social aspect. Participants found the quote in the leaflet informing them that they could do yoga to the extent suitable for them reassuring. Not using jargon and patronising language was also appreciated. However, a booklet format was suggested as the participants felt that they may struggle to carry the leaflet. Adding information on venues offering yoga, types of yoga suitable for older adults, contact details, and website would be useful to participants. If the leaflet was advertising a particular yoga programme, it was important to provide specific information about the programme and elaborate on how exactly it was tailored to suit older adults.

Best practice in media campaigns includes three sequential steps (Bauman & Chau, 2009): (i) raising awareness (ii) changing attitudes and social norms and (iii) a call to action. The leaflet successfully addressed all three steps by including information about MS and BC guidelines and benefits of yoga; addressing some perceptions of yoga such the non-competitive element and social interaction; and encouraging all older adults to try yoga. Participants appreciated that the leaflet included pictures of people they could relate to, performing simple postures. Vinoski, Webb, Warren-Findlow, Brewer, and Kiffmeyer (2017) published a study analysing advertisements featuring women in a yoga magazine (Yoga Journal) over the past four decades to understand socio-demographic and appearance attributes. It was found that in recent years, there was less diversity in terms of ethnicity and age among featured models, with more white females in their 20s or 30s. The study also noted the presence of underweight and low-normal weight models across the magazine's publication history. This portrayal of yoga in the media was observed by older adult participants who felt that pictures in books and handouts were usually of young and supple models. Including pictures of older adults in simple postures was an intervention component that was tested in Study 3, and findings indicate that this

issue expressed by the target population was successfully addressed. However, it was suggested that the leaflet should include pictures of men.

5.4.3 Home-based session and handout. There was a clear preference for a class-based session compared to a home-based one. However, a variety of applications of a home-based session were suggested such as facilitating regularity if participants couldn't attend a class or if classes were suspended. The home-based handout could also be used as a mechanism to give people an idea of what yoga involved, which might encourage them to join a class. The instructor should emphasise that yoga should not replace aerobic exercise, as participants may be tempted to follow the home-based handout instead of stepping outdoors for a walk.

Some participants preferred handouts while others conveyed an affinity for videos. If time and resources are available, interventions should try to develop both alternatives. However, in case of resource constraints, handouts would be preferred as they are more widely acceptable and accessible to an older adult population than videos.

5.4.4 Addressing the barrier of lack of information on yoga. The taster session, leaflet and home-based session were found to be effective in addressing the barrier relating to lack of information on yoga. For yoga studios using the leaflet as a template, it would be important to add information about the specific programme being promoted, and its suitability for an older adult population.

5.4.5 Delivery of the taster session by the instructor. The interview with the instructor helped evaluate the brief prepared, and the process of conveying the essence of the programme. The instructor felt that the principles and aims of the programme were clear, but the brief could have been improved by adding a diagrammatic presentation of the postures. Based on feedback from the participants of the study, instructors are advised that they should integrate the intervention components within their own teaching style to enhance the flow of the session. Other feedback from participants included mirroring the audience while demonstrating, and providing guidance for older adult participants on getting up from the floor. The instructor provided suggestions on the session structure, such as including some

stimulation through breathing exercises after the corpse pose. The instructor also included some additional dynamic repetitive exercises within the warm up.

The instructor mentioned that there would be some effort involved in practicing yoga, which is in contrast with the view that participants should not force themselves. This brings to focus some dualities in the philosophy of yoga which teaches non-violence towards oneself on one hand, and optimising potential on the other.

5.5 Strengths and Limitations

One of the strengths of the study is the use of mixed methods. Mixed methods is an approach that can be used in the exploration of diverse perspectives, and provides research participants with multiple avenues to voice their experiences (Shorten & Smith, 2017). The use of questionnaires, focus groups and interviews in Study 3 produced rich data both at an individual and group level. Using different data collection methods granted advantages of group dynamics (focus groups) and anonymity. Data triangulation revealed that while data was usually validated, there were instances when responses favourable to yoga were presented during the focus groups and in the questionnaire, but less positive sentiments were shared during individual interviews. This could be because the individual was influenced by the positive mood among participants immediately after the session, but with time and after individual practice was less enthusiastic about yoga. The use of varied data collection techniques helped capture these human inconsistencies, and it was important to get these perspectives to truly gauge the appeal of the intervention being developed.

The delivery of the sessions by an instructor external to the research team helped evaluate the fidelity of the programme, which is important for further testing and dissemination (Nutbeam & Bauman, 2014). Programme delivery and evaluation by the lead researcher (who is also a yoga teacher) might have led to biased responses from the participants as they may have been less comfortable about providing negative feedback.

The limitations relating to the sample are similar to those from Study 2. Since a large proportion of the participants were recruited from leisure or fitness centres, they were more likely to be already active and from a higher socio-economic strata. Moreover, PA levels and medical history were not recorded in an effort to reduce participant burden. Future research should evaluate the appeal and acceptability of the final intervention among less active population and those from lower socio-economic sections. Although some facts on medical history were revealed during the focus groups, activity levels of the group, and influence of a disease or condition could not be evaluated systematically.

Reliable and valid instruments were not used to assess enjoyment, difficulty, embarrassment and intentions to participate in future yoga sessions. While instruments are available to assess enjoyment (Mullen et al., 2011) and difficulty (RPE using the Borg Rating of Perceived Exertion scale), these were not used so as to maintain consistency between the four questions. Although the scales used were simple and required minimal time to complete, a limitation of the study was that the validity and reliability of the four scales used could be questioned.

5.6 Summary and Next Steps

In summary, intervention components incorporated within taster sessions, leaflets and home-based sessions supported by a handout were assessed in this chapter (Chapter 5, Study 3) and found to be appealing, appropriate and acceptable to older adults. Intervention components and strategies to promote yoga were refined and further components identified. Inputs from Study 1 (Chapter 3), Study 2 and KE event (Chapter 4), and Study 3 (Chapter 5) were integrated along with findings from other published research studies on yoga to develop the final yoga programme in Study 4 (Chapter 6).

Chapter 6. Final Yoga Programme

The aim of this PhD is to develop a yoga programme that is appealing, appropriate and acceptable to older adults in Scotland.

The components of the final yoga programme were compiled from the following sources:

1. Study 1 of the PhD project was a systematic review of RCTs to assess the effectiveness of yoga in improving physical function and HRQoL outcomes in older adults not characterised by a particular clinical condition.
2. Study 2 of the PhD project was a qualitative study to understand how older adults, with yoga experience and those with no yoga experience, perceive yoga. The study provided insights into the apprehensions older adults may have with yoga, perceived benefits and reasons for the gendered nature of participation. Guidance for instructors and strategies to encourage yoga participation were also compiled.
3. A KE event was conducted where participants included yoga teachers, studio owners and researchers. Research findings were shared with participants during the event and their inputs were procured.
4. Study 3 of the PhD project involved testing of intervention components identified in Study 2 and the KE event. These were incorporated within three elements- yoga taster sessions, a leaflet to promote yoga participation, and home-based practice supported by a handout. These components were then evaluated using mixed methods. Feedback and instructor's perspectives on intervention components and promotion strategies were recorded.
5. Key studies identified from academic literature:

   5a. Practical guidelines for healthcare professionals and yoga teachers interested in working with older adults developed by Bonura (2011)

   5b. A cross-sectional study to identify barriers and cues to participation in a yoga intervention among community dwelling older adults (Nayak et al., 2015)

   5c. A study comparing pathways to yoga, benefits, motivations and barriers to yoga participation in middle-and older-aged adults (Wertman et al., 2016)

5d. A qualitative study that used focus groups to understand pre and post-intervention perceptions to a beginners yoga programme (Patel et al., 2011). The study captured reasons for participation, and perceived benefits of the intervention.

5e. A qualitative study that used a phenomenological approach to explore the yoga experiences of older women in the UK (Humberstone & Cutler-Riddick, 2015)

Intervention components can be defined as aspects of the intervention essential to achieving the outcomes in the target population (Michie, Fixsen, Grimshaw, & Eccles, 2009). These could relate to modes of delivery, setting, content, strategies to promote engagement or adherence, steps to improve fidelity, or aspects of implementation or dissemination (Collins et al., 2013; Michie et al., 2013). Intervention components for the final programme were compiled under the following themes. The complete list of intervention components are presented in tables 24 to 31 and are discussed below:

1. Components to make the yoga programme less difficult and demanding
2. Components to reduce continuous movement between getting up and down from the floor
3. Class content: class structure, postures to include and avoid, progressive nature of programme, suggested yoga poses for strength and balance, home-based session details
4. Breathing/spiritual content
5. Guidance for instructors
6. Components to encourage social interaction
7. Class details: Class environment, class size, duration and frequency, name of the programme, age-group
8. Yoga promotion strategies

6.1 Components to make the Yoga Programme Less Difficult and Demanding

In Study 2, participants with no prior yoga experience perceived that yoga would be difficult and demanding. To address this barrier, adopting a gentle pace, avoiding complicated movements, using props and having options for seated exercises have been included as intervention components (Table 24). Adopting a

gentle pace, using props and having options for seated exercises were also mentioned during the KE event. In Study 3, all these strategies were tested as a part of the taster session, and results from the administered questionnaire and focus group discussions confirmed that participants did not find the session difficult. Using props such as chairs has been found to be helpful to older adults (Patel et al., 2011), and providing chairs to those who need support during standing poses or are uncomfortable sitting on the floor has been suggested (Bonura, 2011). Participants in Study 2 recommended that movement between postures should be gentle. This was also mentioned by Bonura (2011), who also advised that adequate rest should be provided between postures.

6.2 Components to Reduce Continuous Movement between getting Up and Down from the Floor

In Study 2, the participants with no prior yoga experience expressed anxieties about having to continuously move between getting down on the floor and getting up again. They mentioned wanting to only work on standing postures while standing, and then only on postures on the floor, after which they would need to get up only when the class ended. To address this, clustering standing, sitting and lying down postures has been included as an intervention component (Table 25). This strategy was also mentioned in the KE event. Participants appreciated this aspect during the taster session in Study 3. They felt that they would be more relaxed during the class if they knew that they wouldn't have to keep moving up and down. The participants mentioned that instructions on how to get up from the floor after lying down should be provided by the instructor.

6.3 Class Content

6.3.1 Class structure. The most common class structure followed by RCTs included in the systematic review was a warm up, followed by the main postures, and ending with relaxation, breathing and meditation (Table 26). This structure was supported by qualitative data from Study 2. Longer warm ups, including dynamic movement was suggested in the KE session and by the instructor in Study 3.

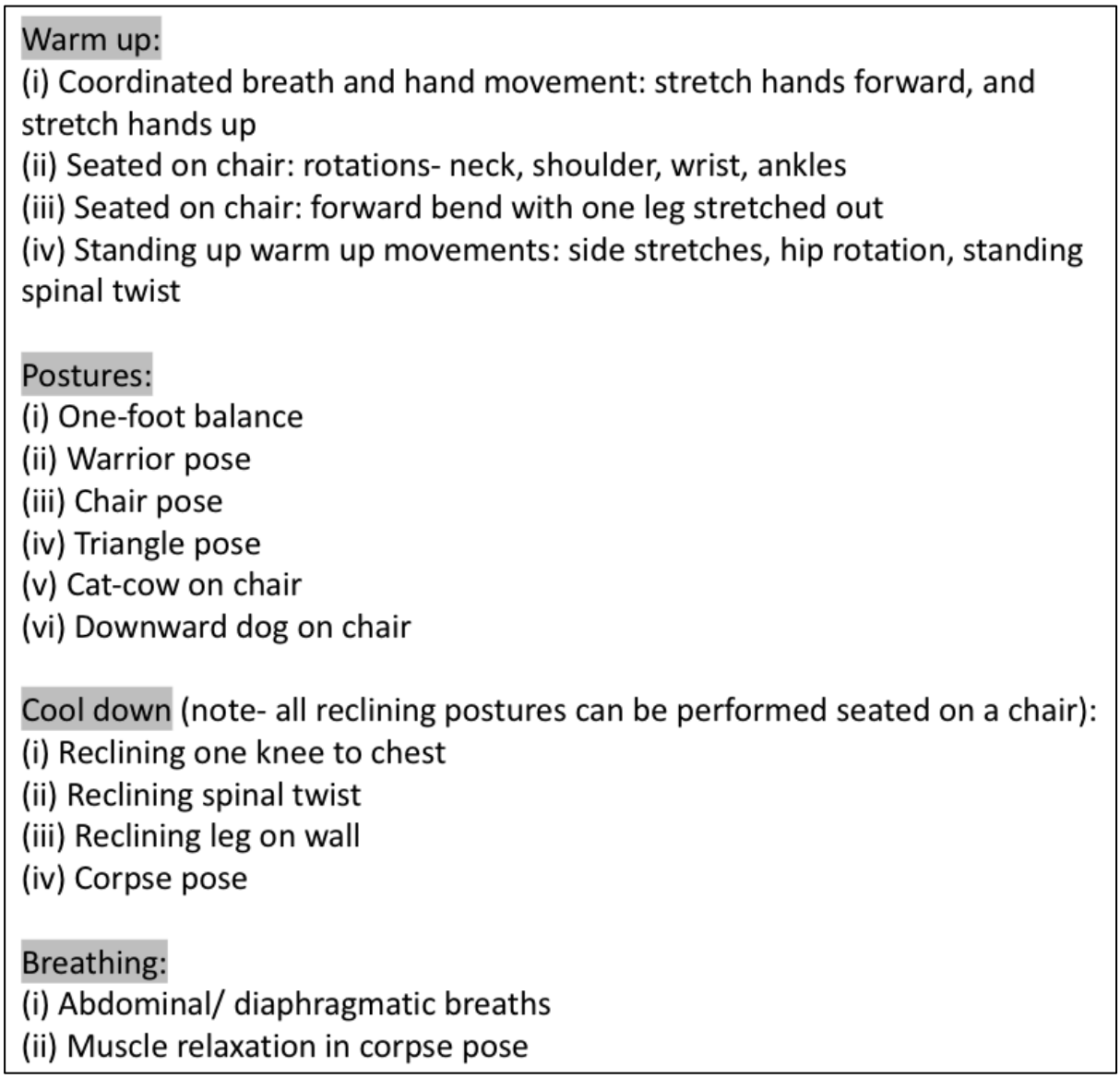
6.3.2 Postures and practices to include and avoid. Holding postures was recommended during the KE event. It was also suggested that older adults should avoid inversions. This is supported by a systematic review of case reports and case series on adverse events associated with yoga, which reported that the headstand and shoulder stand were among postures most often associated with adverse events (Cramer, Krucoff, et al., 2013). Bonura (2011) also recommended that individual with osteoporosis should avoid inversions like shoulder stands and headstands, and those with glaucoma should avoid all postures where the head is below the heart. An intervention component advising caution during inversions has been included in the final programme.

Bonura (2011) also suggested avoiding hot yoga practices and jumping into yoga poses. Cramer and colleagues also found that Bikram yoga was associated with adverse events, and authors cautioned that this style could be inappropriate for older adults and people with medical conditions due to extreme heat and intensity of practice (Cramer, Krucoff, et al., 2013). This guidance could be extended to all hot yoga practices as there is a risk of overheating and stress on cardiovascular function (Bonura, 2011). High impact activities such as jumping have been found to have a favourable effect on bone health (Department of Health, 2011). However, avoiding jumping makes intuitive sense and it may lead to adverse events, and older adults may find it difficult or demanding.

A list of postures that were commonly used in studies (in four or more studies) included in the systematic review (Study 1) have been compiled-
(i) Cat and cow pose (ii) Tree position (iii) Triangle position (iv) Seated twists (v) Mountain pose (vi) Warrior 1 (vii) Cobra (viii) Chair pose (ix) Eagle or Half eagle (x) Locust posture (xi) Downward dog (xii) Wind relieving pose (xiii) Child's Pose (xiv) Hands on feet (xv) Cow face pose (xvi) Shavasana (used for relaxation)

Figure 34 is a sample yoga class with the structure and postures (provided to instructor who delivered the taster session in Study 3). Postures from two studies have also been provided as examples and can be accessed in the supplementary

section (Appendix 38, 39). One study is the only RCT conducted in the UK that included older adult participants with no clinical conditions (Tew et al., 2017). The study was included in the systematic review (Study 1), and followed the British Wheel of Yoga Gentle Years Programme (Appendix 38). The other sample (Appendix 39) is from a study providing practical guidelines for healthcare professionals and yoga teachers interested in working with older adults (Bonura, 2011). This paper has been used as a reference in developing this final intervention.


Warm up:
(i) Coordinated breath and hand movement: stretch hands forward, and stretch hands up
(ii) Seated on chair: rotations- neck, shoulder, wrist, ankles
(iii) Seated on chair: forward bend with one leg stretched out
(iv) Standing up warm up movements: side stretches, hip rotation, standing spinal twist

Postures:
(i) One-foot balance
(ii) Warrior pose
(iii) Chair pose
(iv) Triangle pose
(v) Cat-cow on chair
(vi) Downward dog on chair

Cool down (note- all reclining postures can be performed seated on a chair):
(i) Reclining one knee to chest
(ii) Reclining spinal twist
(iii) Reclining leg on wall
(iv) Corpse pose

Breathing:
(i) Abdominal/ diaphragmatic breaths
(ii) Muscle relaxation in corpse pose

Figure 34. Sample structure and postures provided to the instructor delivering the Study 3 taster session

6.3.3 Autonomy. There is a debate in yoga literature between standardisation of a yoga programme and individualisation or adaptability. For example, experts from a Delphi survey establishing key components of a yoga programme for musculoskeletal conditions felt that the intervention should be reproducible, but not too restrictive or prescriptive (Ward, Stebbings, Sherman, Cherkin, & Baxter, 2014). Similar concerns regarding incorporating progressiveness and variety within standardised protocols, and whether they would constrain instructors has been expressed in a study providing guidelines for designing yoga interventions for RCTs (Sherman, 2012). However, it has been suggested that fully describing the degree of variability and pilot testing of the intervention will help to ensure that teachers are able to deliver the intervention and participants experience no difficulties.

The final programme developed in this PhD does not prescribe a rigid set of postures, or a particular style, and instead provides guidance, and a broad structure with sample postures. This provides instructors with the autonomy to integrate these guidelines within their own practice and style, and come up with their own sequences for each class. This ensures that the creativity and individuality of each yoga teacher is not stifled. This design was evaluated in Study 3, and although the instructor had some teething troubles in the very first taster session, he grew comfortable and confident in the following sessions. Since this programme does not have pre-defined postures, it is even more important that instructors receive adequate training relating to yoga for older adults.

6.3.4 The programme should be progressive. One recommendation from the KE event was that the yoga programme should be progressive. It was felt that a progressive programme would be more appealing to male older adults. Progression is an aspect of the ACSM PA recommendations (Garber et al., 2011). With respect to resistance exercises, the prescription includes "gradual progression of greater resistance, and/or more repetitions per set, and/or increasing frequency" (Garber et al., 2011, p. 1336)

In a yoga programme, progression could take the form of:

a. Advancing from an easy variation of a pose to an advanced version of the pose

b. Including more demanding and advanced poses
c. Increasing the amount of time you hold particular pose or the number of times you attempt a pose
d. Including techniques like vinyasa or a flow of postures synchronized with breathing
e. Going deeper into a yoga pose or advancing within a pose, for example stretching more in a forward bend

The principles of non-violence and no pain (discussed in detail later) should be kept in mind during progression in a yoga programme

6.3.4.1 Examples of easy, intermediate and advanced yoga poses. Yu et al. (Yu et al., 2012) recorded the joint moment of force (JMOF) and muscular activation in the lower extremities (using electromyographic signals of lower gluteus medius, hamstrings, vastus lateralis, and gastrocnemius muscles of the dominant limb) for three versions (introductory, intermediate and advanced) of the tree pose and one-leg balance pose (Figure 35). For the tree pose, the introductory pose included wall support and toes on the floor (TreeWF), the intermediate pose only had wall support (TreeW), and the advanced version was the classical tree pose (Tree). For the introductory one-leg balance (OLBb), participants stood on one leg and placed the other leg on a block with the knee flexed to 90 degrees. For, the intermediate pose (OLBc), participants stood on one leg and extended the other leg to rest on a chair. In the advanced pose (OLB) participant stood on one leg and held the other raised above the ground, keeping it extended with no support.

It was found that the overall demand of the lower extremity indicated by support moment (sum of the individual extensor moment at the hip, knee and ankle) was the highest for the advanced Tree followed by TreeW, and then TreeWF. The greatest increase in demand was from TreeWF to TreeW, as compared to transition from TreeW to Tree. Authors concluded that yoga practitioners would need to practice more to move from introductory to the intermediate pose, but the progression from intermediate to the advanced pose would be easier. There was no significant difference between the Tree and TreeW with respect to the hip and knee JMOF in both sagittal and frontal planes.

For the one-leg balance, the overall demand (indicated by support moment) for the advanced OLB was significantly greater than OLBc and OLBb. But the average support moment did not significantly differ between OLBc and OLBb. Authors commented that more effort would be required to transition from the introductory and intermediate pose to the advanced pose. Moreover, the direction of the sagittal JMOF for OLBb and OLBc was opposite to the advanced OLB and were likely to target antagonistic muscle groups.

The inference from this study is that for some postures such as the tree pose, the overall demand is the highest for the advanced posture followed by intermediate and then the introductory. Whereas for other postures such as the one-leg balance, there was no difference in the overall demand between the introductory and intermediate poses. Perhaps, there are other parameters such as ease of balancing that would make intermediate and advanced postures more challenging. Interestingly, the different variations of the pose could also activate different muscles. While more research on posture variation would aid the selection of the right modifications for participants to ensure suitability and progression, instructors currently make the decisions based on intuition.

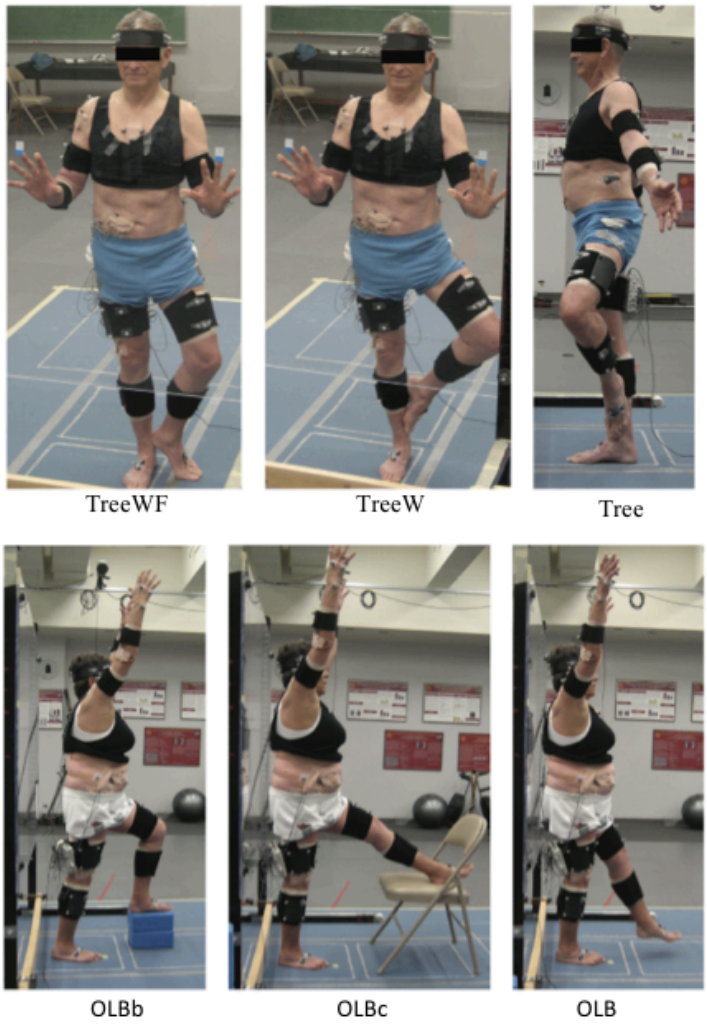


Figure 35. Illustration of introductory, intermediate and advanced versions of the tree pose and one-leg balance pose. Reprinted from "The Physical Demands of the Tree (Vriksasana) and One-Leg Balance (Utthita Hasta Padangusthasana) Poses Performed by Seniors: A Biomechanical Examination" by Yu et al., 2012, Evidence-based Complementary and Alternative Medicine. Copyright [2012] by Sean S.-Y. Yu et al. Permission not required under the Creative Commons Attribution License.

Participants from Study 2 and the KE event felt that it was important to establish some method of monitoring progress. This could be done by bringing attention to the fact that participants are attempting advanced versions of postures, or making them aware of their bodies and if they are going deeper in any particular posture. Small victories such as reduced discomfort while performing postures, reduced pain as a consequence of yoga practice, benefits of yoga such as better sleep could also be pointed out.

6.3.5 Balance between monotony and introducing new exercises.

Participants from both Study 2 and Study 3 appreciated variety, and felt classes should not get too repetitive. However, they also felt they would get confused if too many new exercises were introduced. They suggested introducing limited new postures each week. This has been added as a programme component within this final programme to ensure that in each session there are some old exercises which participants are comfortable with and a few new ones to add variety, elements of progression and challenge.

6.3.6 Physical activity guidelines. In addition to aerobic activities, UK PA recommendations for older adults include undertaking MS activities on at least two days a week (Department of Health, 2011). Older adults at risk of falls should also participate in BC activities on at least two days a week (Department of Health, 2011). It is recommend that MS activities should work all the large muscle groups of the body (Department of Health, 2011). Similarly, ACSM recommendations for older adults also include MS activities and advocate participation in a resistance programme including dynamic exercises that recruit multiple muscle groups such as chest, shoulders, back, hips, legs, trunk and arms (Garber et al., 2011).

In Study 1, yoga was found to improve strength (lower body strength) and balance in older adult participants when compared to inactive controls. The review concluded that yoga could be promoted within PA guidelines as an activity that promotes strength and balance. Hence considering MS and BC guidelines, and incorporating postures to improve strength and balance has been included as a programme component.

6.3.6.1 Yoga poses for building strength. Ni, Mooney, Harriell, Balachandran, and Signorile (2014) recorded surface electromyographic (EMG) signals of specific trunk and hip muscles for 11 yoga poses. Participants in the study were healthy young yoga practitioners. Activation of specific muscles compared to other muscles for yoga poses suitable for older adults are presented in Table 21.

Table 21.

Activation of core muscles during yoga poses

Posture	Activation of muscles
Halfway forward bend	Longissimus thoracis, external oblique abdominis, gluteus maximus
Full forward bend	External oblique abdominis, gluteus maximus
Downward dog	External oblique abdominis
Upward dog	External oblique abdominis, longissimus thoracis
Chair	Gluteus maximus, external oblique abdominis, longissimus thoracis strength, rectus abdominus
Mountain pose arms down and arms up	External oblique abdominis
Warrior 1	Gluteus maximus strength, external oblique abdominis, longissimus thoracis.

Note. Based on results from "Core muscle function during specific yoga poses" by Ni, Mooney, Harriell, et al., 2014, *Complementary Therapies in Medicine*.

Beazley, Patel, Davis, Vinson, and Bolgla (2017) quantified activation of trunk and hip muscles (rectus abdominis, abdominal obliques, lumbar extensors, and gluteus maximus) during yoga poses using surface EMG. Participants were young adults with minimal yoga experience. EMG activity was expressed as a percentage of maximum voluntary isometric contractions (MVIC) for each muscle. Authors used the following activation ranges to aid interpretation: 0–20% MVIC (low); 21–40% MVIC (moderate); 41–60% MVIC (high); and greater than 60% MVIC (very high). Three (upward dog, chair pose, warrior 1) of the four yoga poses studied were suitable for older adults and the muscle activation patterns are as follows:
EMG activity for the rectus abdominus was low for all three poses. Abdominal obliques activation was also low with moderate activation during upward dog. Moderate activation of lumbar extensors was observed during the chair pose. And low-to moderate (20.4%) activation of gluteus maximus was observed during the upward dog. Muscle activation for the poses can be summarised as follows-
Upward dog: moderate abdominal obliques activation, low-moderate gluteus maximus activation
Chair: moderate activation of lumbar extensors

Salem et al. (2013) recorded muscle activity of specific muscle groups during static yoga postures using surface EMG signals in older adult yoga practitioners. These were expressed as a percentage of peak EMG signals generated while walking at a self-selected pace. The percentages have been classified as low, moderate, high and very high based on the categories suggested by Beazley et al. (2017). Yoga poses and corresponding muscles with very high or high activation are presented in Table 22.

Table 22

Muscle activation in yoga poses

Pose	**Muscle**	**Muscle activation category**
Chair with wall support	Quadriceps	Very high
	Erector spinae	Very high
	Rectus abdominis	Very high
Tree with wall and toes on floor	Rectus abdominis	High
Downward facing dog with wall support	Erector spinae	Very high
	Rectus abdominis	High
	Hamstring	High
Warrior I with chair—front limb	Rectus abdominis	Very high
	Quadriceps	High
	Erector spinae	Very high
Warrior I with chair—back limb	Rectus abdominis	Very high
	Quadriceps	High
	Erector spinae	High
Warrior II with chair—front limb	Quadriceps	Very high
	Rectus abdominis	Very high
Warrior II with chair—back limb	Rectus abdominis	Very high
	Quadriceps	High

Side stretch with wall support front—limb	Rectus abdominis	High
	Erector spinae	High
	Hamstring	High
Side stretch with wall support—back limb	Rectus abdominis	High
	Erector spinae	High
	Hamstring	High
Chair	Erector spinae	Very high
	Quadriceps	Very high
	Rectus abdominis	High
Tree with wall support	Rectus abdominis	High
Tree	Rectus abdominis	High
Warrior II—front limb	Quadriceps	High
	Rectus abdominis	High
	Erector spinae	High
Warrior II—back limb	Rectus abdominis	High
	Erector spinae	High
One-leg balance with blocks	Rectus abdominis	High
	Erector spinae	High
	Quadriceps	High
One-leg balance with chair	Rectus abdominis	Very high
	Quadriceps	High
One-leg balance	Hamstring	Very high
	Rectus abdomini	High
	Gastrocnemius	High
	Gluteus medius	High
	Quadriceps	High

Note. Based on results from "Physical Demand Profiles of Hatha Yoga Postures Performed by Older Adults" by Salem et al., 2013*, Evidence-based Complementary & Alternative Medicine*

Muscle activation categories 0–20% peak EMG signal: low; 21–40% peak EMG signal: moderate; 41–60% peak EMG signal: high; and greater than 60% peak EMG signal: very high (Beazley et al., 2017)

To summarise, a number of poses activate core, trunk, hips and muscles of the lower extremities. However, poses for upper body strength have received less attention. It should also be noted that while the meta-analysis conducted in Study 1 found that lower-body strength was improved by yoga interventions, there was not enough data to draw conclusions about upper body strength. Unlike some activities such as biceps curl which would focus on one muscle group, yoga poses usually work multiple muscles. For example warrior 1 has been found to activate the rectus abdominis, quadriceps and erector spinae (Salem et al., 2013), but with the arms stretched upwards, several upper body muscles could also be activated. The cat-cow pose, triangle pose and downward dog are some other poses that could potentially strengthen upper body muscles. More research evidence is required to understand the effects of yoga on the upper body, as well to identify poses that would strengthen the upper body muscles.

6.3.6.2 Yoga poses for balance. Study 1 included an RCT (Ni, Mooney, Richards, et al., 2014) to assess the effects of a balance yoga intervention compared to standard balance training and tai chi. Their yoga programme was progressive and was specifically designed to improve balance, based on muscle utilisation patterns during yoga poses. The programme included poses and vinyasa (a flow of postures). Some of the postures adopted in the programme are presented in Table 23.

Table 23

Excerpt of postures from a custom designed yoga balance programme

Stage 1	Stage 2	Stage 3
Mountain pose (feet apart)	Mountain pose (feet together)	Mountain pose (feet together)
Mountain pose (arms up) sit down and back into chair pose	Mountain pose (arms up) sit down and back into chair pose	Mountain pose → forward fold
Lateral side stretch	Crescent lunge	Sun A: Mountain pose/Forward fold/Halfway lift/Low lunge Rt leg/Halfway lift/Forward fold/Mountain pose/Forward fold/Halway lift/ Low lunge Lt leg
Crescent lunge	Mountain pose (arms up) → Chair pose → Mountain pose	Sun B: Chair pose/Forward fold/Halfway lift/High lunge Rt leg/Halfway lift/Forward fold/Chair pose/Forward fold/Halfway lift/ High lunge Lt leg
Mountain pose (arms up) → Chair pose → Mountain pose	Warrior 1 pose	Warrior 1/Warrior 2/Reverse warrior/Extended side angle
Warrior 1 pose	Mountain pose (arms up) → Chair pose → Mountain pose	Crescent lunge
Mountain pose (arms up) → Chair pose → Mountain pose	Chair pose with twist	Low lunge
Chair pose with twist	Lowering to the floor	Low to high lunge twist
Lowering to the floor	Table top (Bird Dog) alternate arm and leg extension	Mountain pose/ Chair pose/ Chair pose with twist
Table top (Bird Dog) alternate arm and leg extension	Child pose	Lowering to the floor
Modified plank pose	All fours knee lifts	Table top (Bird Dog) alternate arm and leg extension
Modified croc hops	Forearm plank pose	Child pose
Child pose	Low lunge into twist	All fours knee lifts
Low lunge	Down dog pose	Forearm plank pose
Down dog pose	Modified croc hops	Croc hops
All fours knee lifts	Plank pose (ten breaths)	Side plank pose

Note. Adapted from "Comparative impacts of Tai Chi, balance training, and a specially-designed yoga programme on balance in older fallers" by Ni, Mooney, Richards, et al., 2014, *Archives of Physical Medicine and Rehabilitation.* Copyright [2014] by American Congress of Rehabilitation Medicine.

Some poses and flows presented even in Stage 1 of this programme (Ni, Mooney, Richards, et al., 2014) may be considered difficult and inappropriate for older adults (Figure 36). Modifications of these postures using a chair could make them more suitable for this population.

Figure 36. Stage 1 postures from a custom designed yoga balance programme that may be considered inappropriate for older adults. Reprinted from "Comparative impacts of Tai Chi, balance training, and a specially-designed yoga programme on balance in older fallers" by Ni, Mooney, Richards, et al., 2014, Archives of Physical Medicine and Rehabilitation. Copyright [2014] by American Congress of Rehabilitation Medicine. Reprinted with permission.

The balance poses used in the study by Tew et al, (2017) including heel raises, toe raises, one-foot balance, hip abduction, and tree pose (Appendix 38) are appropriate for older adults. Half eagle, one-leg balance, downward dog and bird-dog are other poses that can be performed using a chair if required and are appropriate for older adults.

6.3.7 Home-based sessions. Although participants in Study 3 expressed a preference for class-based sessions, enabling older adults to practice yoga at home could be very valuable. Older adult participants felt that home-based sessions could be very useful to beginners and would potentially enhance frequency of exercise participation. Yoga participants have mentioned practicing stretching, breathing and relaxation techniques at home (Study 2; Patel et al. (2011)). Some strategies to encourage home-based yoga practice have been compiled. Handouts and videos can be used as material to aid home-based practice. Results from Study 3 indicated that handouts are a viable medium to support home-based practice, and if the programme has limited resources, then handouts are more acceptable and accessible to this population than videos. Handouts were suggested as a medium for home practice at the KE event as well. In both Study 2 and 3, participants expressed that they would be more comfortable practicing exercises at home, if they have done them before

under the supervision of an instructor. The instructor should ensure that all the exercises suggested in the handout are covered in class, and should highlight all the featured postures. This is only relevant if the programme consists of class-based and home-based components. Participants in Study 3 found it useful that a chair was used to perform the postures in the handout, but they should be advised to use a stable chair of the appropriate height. A strategy suggested by participants in Study 3 to improve adherence to home-based practice was regular follow ups via phone. Substituting aerobic exercise such as walking with the home-based exercises was noted in Study 3, and participants should be discouraged from this. Some participants enquired about the appropriateness of practicing the postures while engaging in other activities such as watching television. In the interest of increasing PA and breaking up sedentary behaviour, it is advised that participants can work on the home-based poses while doing some other simple activities.

6.3.7.1 Home-based handouts. Participants from both study 2 and 3 suggested that the handout for home-based practice should be simple, and use pictures of older adults. The bulk of suggestions from Study 3 centred around clarity of instruction. Providing modifications to make the posture simpler or more challenging has been suggested. Intermediate and advanced postures could be introduced when the participants have more experience with yoga. Providing some breathing and relaxation techniques has been suggested in studies 2 and 3. This is also supported by findings from the study by Patel et al. (2011) where participants reported practicing particularly the relaxation exercises at home. Creating a series of home-based handouts which are progressive was suggested in Study 3.

6.4 Breathing/Spiritual Content

A barrier to participation among those with no previous yoga experience identified in Study 2, was the perception that yoga would have high spiritual and meditative content. Wertman et al. (2016) found that older adults were less likely than younger adults to pursue yoga to explore spirituality, and were also less likely to seek yoga for the purpose of mediation. Limited spiritual and philosophical content was also preferred by participants in the study by Humberstone and Cutler-Riddick

(2015). However, yoga participants in Study 2 as well as the study by Patel et al. (2011) have expressed that they enjoy the breathing, meditation and spiritual aspects. Hence, breathing and meditation should be included within a yoga programme, but should not form a major component (Table 27). This was tested in Study 3 where it was found that participants enjoyed the breathing and relaxation and expressed that the short duration of these elements (approximately 5-7 minutes of the total 30 minutes session) was optimal. Making yoga less contemplative was also a strategy suggested in Study 2 to encourage yoga participation among male older adults.

The intervention components stressed the importance of breathing, and relaxation whilst in the corpse pose. This was mentioned in the KE event, as well as in the Bonura (2011) guidelines. Yoga participants also felt that relaxation in the corpse pose was essential. In Study 3, the instructor suggested including some breathing after the corpse pose to provide some activation, as the pose could be too relaxing.

While some participants in Study 2 preferred breathing at the beginning of the session, others preferred it at the end. Breathing could be used for multiple purposes, as a warm up as well as a cool down and a relaxation technique. The instructor could decide on when the breathing would be performed and could change the sequence to bring some variation to the sessions. Bonura (2011) advised avoiding breathing practices that involve rapid breathing or holding the breath. The systematic review assessing adverse events related to yoga, found that yoga breathing practices were associated with adverse events (Cramer, Krucoff, et al., 2013). They suggested that gentle forms of yoga breathing, such as the abdominal breath, may be appropriate for beginners, and extreme forms that involve holding the breath or forceful techniques like Kapalabathi should be avoided by those new to yoga.

The feedback on the taster session from Study 3 conveyed that participants found breathing during postures very confusing. Instructors could provide more explanation or detailed instructions on breathing during postures. They could convey to participants that coordinating breath and movement takes time and practice, and that they should not get discouraged if they find it difficult initially. There is

however a need to develop a rule of thumb breathing pattern that can be applied while performing postures. During the focus group session, there were discussions around breathing while performing postures, and the primary researcher explained that in yoga, you inhale when you open out the body and exhale when you contract. Participants found this useful. While this is oversimplified, a rule of thumb could help with the confusion around this aspect of yoga.

6.5 Guidance for Instructors. Nayak et al. (2015) found that a dislike of the teacher was a significant barrier. They acknowledged that the teacher plays an integral part in encouraging participation and stressed the importance of an experienced teacher in accommodating the variation in fitness levels and capabilities which is characteristic of an older adult population. Endeavouring to make the session accessible to all older adults was emphasised by Bonura (2011), and participants at the KE event provided strategies to create a programme that's welcoming and accessible to older adults with different capabilities, fitness levels and health conditions. These strategies would minimise pain, discomfort and adverse events during a yoga session and increase the appeal, appropriateness and acceptability of the yoga programme. Participants in Study 2 provided insights into the qualities they would appreciate in an instructor, and suggestions for the effective delivery of a yoga class. These strategies helped develop guidelines for instructors (Table 28), and have been incorporated as intervention components under nine themes.

6.5.1 Asking about health conditions and injuries. Participants from Study 2 felt that the instructor should be caring, and take an interest in each individual. Findings from Studies 2 and 3 included asking about health conditions and injuries. Checking for hearing and sight impairments was mentioned at the KE event and was also recommended by Bonura (2011). Several other recommendations such as offering subtle options to disclose health related issues, and asking older adults with impairments for suggestions on how to improve the yoga experience for them, and setting expectations as the benefits of yoga may be long-term were also compiled.

6.5.2 Creating a non-competitive environment and reducing embarrassment. Feeling embarrassed was cited as a barrier to participation among NYPs in Study 2, who felt that they would be embarrassed if they couldn't keep up with the rest of the class. An important intervention component aiming to create a non-competitive environment and reduce embarrassment compiled from Studies 2, 3 and the KE event was conveying to participants that they could choose their own pace, and could avoid postures or movements they were not comfortable with. A non-violent approach was advocated by the taster session instructor (Study 3), in which one did not force themselves to perform postures. Moving away from competition and judgement was also addressed in the study by Humberstone and Cutler-Riddick (2015). Instead of comparison, participants should be encouraged to be in the moment, and feel the body movement synchronised with breathing Humberstone and Cutler-Riddick (2015). Awareness and mindfulness are important concepts in yoga and encouraging participants to be aware of their bodies and limitations, and to be mindful during the session would limit self-judgement, and also reduce pain and risk of injuries. Eschewing competitiveness and not aiming for the perfect posture were suggested (Bonura, 2011; Humberstone & Cutler-Riddick, 2015). Encouraging participants to take breaks whenever needed was another included component (Bonura, 2011).

6.5.3 Understanding older adults. Study 2 and KE participants considered it important that instructors understand older adults and the physiology of ageing. Humberstone and Cutler-Riddick (2015) also felt that it was important that older adult participants are given the space in a yoga class to reflect on their bodies and changes that come with ageing. Presenting positive images of older adults in a yoga class and providing examples of inspiring, capable older adults was also stressed on (Humberstone & Cutler-Riddick, 2015). Humberstone and Cutler-Riddick (2015) stressed the importance of the teacher being sensitive to the needs of students. Proffered instructor qualities compiled from consultations with the older adult population have been included within the intervention components.

6.5.4 Challenge but not pain. While the instructor should strive to deliver a class that is challenging as suggested in Study 2 as well as the KE event, yoga participants should not be in pain. This was also advocated by Bonura (2011) who felt that the level of exertion should be reduced if discomfort is experienced. If the pain persists, participants should be advised to discontinue yoga till a doctor is consulted.

6.5.5 Offering posture modifications. Offering posture modifications, suggesting easier options and using props if required are extremely important while delivering a yoga session for an older adult population (Study 2, KE event, Humberstone and Cutler-Riddick (2015)). This would help accommodate different capabilities, health conditions and fitness levels. Starting with the simplest pose and then demonstrating more complicated modifications was suggested (instructor interview, (Bonura, 2011)). The taster session instructor advised that if no modifications of a pose were possible, then participants should avoid the pose if they found it taxing. KE participants felt that instructors should have a knowledge of adaptations of postures and contraindications for common health conditions.

6.5.6 Demonstration. The importance of demonstrating was emphasised in Study 2 and at the KE event. Strategies to demonstrate effectively were suggested in Study 3 including using different planes and angles, demonstrating the simple version of a posture (to be practiced during the session), and also the advanced version, so that participants could understand the movement required and the final aim. However, participants at the KE event dissuaded instructors from unnecessarily demonstrating advanced postures to show off. Study 3 participants felt that the instructor should mirror the audience, and this component was supported by Bonura (2011).

6.5.7 Communication. Several communication strategies were compiled from Study 2 and the KE event. Bonura (2011) added that the language and class format should be adjusted according to the participants' comfort levels with eastern languages and influences. Judgemental, negative, age-related language should be

avoided, adopting positive and encouraging language. In Study 3, explanations from the instructor (such as body part being worked on) were appreciated by participants. Based on feedback from Study 3 participants, it was felt that instructors should internalise the principles of the yoga programme, and integrate it with their own yoga style to create a natural flow.

6.5.8 Correcting postures. Study 3 participants felt that the instructor should move around the room to correct and adjust postures. Results from Study 2 and Bonura (2011) indicated that manual correction of postures by instructors should be avoided, and verbal correction should be resorted to instead.

6.5.9 Training and experience. Training and experience of an instructor was found to be very important to participants in Study 2. It is also essential that training on the following topics be provided to instructors when working with older adults-

1. Posture modifications for specific conditions
2. Postures for each major muscle group including upper body muscles
3. Progression for each posture- introductory, intermediate and advanced versions of postures
4. Strategies to be adopted to ensure that the yoga programme is appealing, acceptable and appropriate for older adults including obtaining information on health conditions, communication etc
5. Understanding the physiology of ageing
6. Recent research on yoga for older adults

Since this programme is designed with the intention of improving MS and BC in older adults, it is important that instructors are aware of the PA guidelines for older adults (Department of Health, 2011). While this PhD thesis provides information on the above topics, further research on posture modifications, variations and postures for strengthening major muscle groups is required.

6.6 Social Interaction

Yoga participants from Study 2 appreciated the social aspect of the yoga class. They regularly met up for coffee after the class, and expressed that they felt included and supported. It is thus recommended that yoga programmes provide opportunities for social interaction (Table 29). Bonura (2011) also suggested that instructors allow time for interaction before, after and during class.

6.7 Class Details

6.7.1 Class environment. Several strategies to create a comfortable ambiance for participants have been suggested (Table 30) such as pleasant temperature, cleanliness, and good lighting. Requisite props such as chairs, mats and blocks should be provided. During the class, mats should be arranged so that participants are not infringing on anyone else's space, and there is enough space to stretch their arms out. Choosing a quiet location and avoiding music was suggested in the KE event and by Bonura (2011), so that the programme is accessible to those with hearing difficulties. Bonura (2011) also endorsed avoiding incense or candles to suit those with COPD.

6.7.2 Attire. Lack of information was found to be a barrier to participation in Study 2, and this included lack of information on the appropriate attire for a yoga class. Taster session participants (Study 3) also mentioned that they would have liked more information on what clothing and shoes would be appropriate for the session. Bonura (2011) suggested that students should be allowed to attend the yoga class keeping shoes on in case of foot conditions, balance issues, or physical/psychological discomfort with being barefoot. This is contrary to standard yoga practice which is performed barefoot. However, most participants in Study 3 wore their shoes during the taster session, and one participant who wore socks provided feedback that he felt unstable during the session. Participants should be warned that performing postures wearing only socks could lead to reduced stability and increased risk of slipping.

6.7.3 Class size. Participants in Studies 2 and 3 expressed a preference for a smaller class size, as crowded classes would ruin the ambiance and they would not

receive personalised attention from the teacher. However, if the class is too small, they felt they might receive too much attention. Fifteen to 20 people in a class was mentioned as ideal for participants in Study 2, although the emphasis was on having enough space and being able to see and hear the instructor. Instructors at the KE event felt that bigger classes (more than 10-12 people) are difficult to manage. The instructor from the taster session suggested that larger classes should have 2-3 assistants, so that while one demonstrated, others could walk around and ensure that participants were keeping up with the session.

6.7.4 Duration and frequency class-based. Class-based sessions. Lack of time and duration of classes being too long have been identified as barriers to yoga participation (Nayak et al., 2015; Wertman et al., 2016). Having shorter classes could address these barriers, and 60 minutes was the duration preferred by many NYPs in Study 2 (Table 30). Regular yoga participants from Study 2 were comfortable with longer classes of approximately 90 minutes. The frequency preferred by participants in Study 2 was one or two days a week. In the systematic review (Study 1) the most common duration and frequency of yoga interventions in included studies was 60 minutes and two days a week. Two days a week is also the optimal frequency for undertaking MS and BC activities as per the PA guidelines in the UK (Department of Health, 2011).

6.7.5 Duration and frequency home-based. All but one of the participants in Study 3 were able to perform the home-based exercises on at least two days in a week. Although the protocol did not involve a regular home-based programme, Study 3 provided some evidence that two days per week is a frequency that was acceptable to older adults. Participants in Study 2 felt that while they may not be able to engage in a long home-based session, they were more likely to do a shorter session. A shorter 10-15 minute home-based session was tested in Study 3, and participants were comfortable with this duration.

6.7.6 Age group and level. Some participants in Studies 2 and 3 expressed a preference to attend classes with people of similar ages, while others felt it was

important that they are at the same level or capability as others in the class. This could stem from a fear of not being able to keep up, and the suggestions to reduce embarrassment and create a non-competitive environment could help resolve this. It was mentioned at the KE event that classes should not focus on age, but rather consider the capability and fitness levels of participants. Segregation into different levels of classes if possible without lumping everyone together was also advised.

6.7.7 Gender of the instructor. Having a male instructor was suggested by some participants in Study 2, while others felt that the gender of the instructor would not make any difference. In Study 3, participants mentioned being indifferent to the gender of the instructor. Many of them had worked with a female instructor in other exercise classes, and felt that having a female instructor was not an issue. No specific recommendation regarding the gender of the instructor was made in the final yoga programme.

6.8 Yoga Promotion Strategies

While the earlier sections focused on developing an appealing, acceptable and appropriate intervention, this section provides strategies to encourage yoga participation. Methods to change perceptions that deter older adults from trying or joining a yoga class have been discussed (Table 31).

6.8.1 Taster sessions, leaflets and handouts. Lack of information around yoga was identified as a barrier to yoga participation in Study 2, and participants expressed that they may be more motivated to join if they understood the benefits of yoga. Hence, providing information around yoga and publicising its benefits were suggested as yoga promotion strategies in Study 2. Yoga taster sessions, leaflets and home-based handouts were found to be effective in addressing this barrier (Study 3). It was also found that those who had heard of yoga, had attended or were participating in yoga sessions were more likely to attend future yoga sessions (Nayak et al., 2015), demonstrating that awareness leads to participation. This is another mechanism by which tasters, leaflets and handouts promote yoga participation.

6.8.1.1 Yoga taster sessions. Yoga taster sessions and introductory classes were suggested by older adult participants in Study 2 as ways to introduce people to yoga. Another barrier identified in Study 2 as well in the study by Nayak et al. (2015) was the perception that yoga lacks an aerobic element. Taster sessions can be used as a mechanism to address this barrier by giving participants the opportunity to experience the benefits of yoga. Leaflets can be also be used for this purpose.

Yoga taster sessions would provide older adults with the opportunity to try yoga without investing too much time and money. The session could incorporate all the intervention components, but in just one 30-40 minute session.

6.8.1.2 Leaflets. Leaflets are an effective mode to address some of the apprehensions that older adults have with yoga. Media publicity of yoga was found to be a cue to action in the study by Nayak et al. (2015). Wertman et al. (2016) found that media cues such as posters prompted older adults to join a yoga programme. These findings indicate that promotional leaflets could be one strategy to encourage yoga participation. Leaflets can be used to create awareness about the MS and BC recommendations and that practicing yoga could help meet them. Female participants in the study by Humberstone and Cutler-Riddick (Humberstone & Cutler-Riddick, 2015) took up yoga as a consequence of illness. Concern about diminishing physical capabilities, and managing mental or emotional issues were other reasons for taking up yoga. Reasons for joining yoga classes mentioned by participants in the study by Patel et al. (2011) include improving physical health, managing health conditions, improving strength and mobility, being independent, for relaxation and relieving stress. These benefits of yoga could be publicised to encourage participation. The information on the benefits of yoga presented in the leaflet (Study 3) was appreciated by participants, who were specifically interested in improvements to brain function and memory. Providing information on brain function was recommended at the KE event. This was supported by a meta-analysis of the effects of yoga on cognition (Gothe & McAuley, 2015). The review identified 15 RCTs and found a significant moderate effect ($g = 0.33$) of yoga on cognition. Significant effects favouring yoga were also found for attention and processing speed

(g = 0.29), followed by executive function (g = 0.27) and memory (g = 0.18). In a RCT examining the effects of an 8-week hatha yoga programme on executive function (Gothe et al., 2014), 118 older adults (mean age = 62) were randomised to a yoga group or a stretching-strengthening control (Frequency: 3 sessions per week, duration: 60 mins). Results indicated that yoga significantly improved performance on the executive function measures of working memory capacity and measures of cognitive flexibility (ability to appropriately adjust ones behaviour accordingly to the environment (Dajani & Uddin, 2015)) compared to the stretching-strengthening control. Some participants from Study 3 felt that falls are of great concern to an older adult population, and prevention of falls should be included as a benefit in the leaflet. In the systematic review (Study 1), only three studies reported fear of falls (Morris, 2008; Nick et al., 2016; Tiedemann et al., 2013), and no significant difference between the yoga group and inactive control was found for this outcome. Fall frequency was reported by only 2 studies included in the systematic review (Morris, 2008; Saravanakumar et al., 2014), and no meta-analysis was carried out for this outcome. Both studies reported no significant difference between the yoga group and controls. The systematic review reported significant improvements in balance in the yoga group compared to inactive controls. Since balance has been found to be associated with reduction in falls (Sherrington et al., 2008), it is appropriate to mention in the leaflet that yoga could help with fall reduction. KE event participants also suggested that benefits such as helping with injuries and improvement in sporting ability could make yoga more attractive to male older adults. It is important that the social and non-competitive aspects of yoga are mentioned in the leaflet. The leaflet could have the web address of the NHS yoga website (https://www.nhs.uk/live-well/exercise/guide-to-yoga/), which provides comprehensive information about yoga addressing health benefits, whether it is appropriate for patients with health conditions, and different styles of yoga.

Leaflets could be used to (i) recruit participants for yoga research, (ii) to increase awareness as a strategy to encourage yoga participation, or (iii) to promote a specific yoga programme. A leaflet was designed and evaluated in Study 3, and

strategies to design an appealing and useful leaflet, drawing from Studies 2 and 3 have been compiled (Table 31).

6.8.1.3 Home-based handout. It was felt that home-based handouts could help those new to yoga understand what to expect in a yoga class, and hence encourage them to join a yoga programme.

6.8.2 Other strategies to promote yoga. Other strategies to promote yoga have been compiled (Table 31). Participants in Study 3 were interested in a short summer yoga course to learn the basics and then continue practicing at home. Incorporating some yoga in other exercise classes, promoting yoga through pre-retirement courses and charities, and having positive role models was suggested in Study 2 and the KE event. Having role models for men and promoting yoga through football/rugby/swimming clubs and gyms were strategies suggested in Study 2 and at the KE event to promote yoga among male older adults.

Wertman et al. (2016) found that a neighbour suggesting yoga was a pathway to yoga participation, and Nayak et al. (2015) reported that motivation from friends or family was a cue to action. It was also suggested in Study 2 that people doing yoga should encourage friends and family to participate, and this has been added as a promotion strategy. Showing informative videos and conducting info-demonstrations was suggested during the KE event. In Study 2, perceptions around the name "yoga" was explored, and one strategy suggested was to add a tag line to "yoga" that would elaborate who it is for, what it is, and the benefits.

Promoting yoga medically and through healthcare professionals and physiotherapists was suggested in Study 2 and during the KE event. Bonura (2011) provided guidelines for healthcare professionals and yoga instructors to work collaboratively, and these have been integrated into the yoga promotion strategies. As mentioned during the KE event, instructors could work with healthcare professionals to consider the medical history of participants and determine yoga postures that are contraindicated. Healthcare professionals could also be encouraged

to become familiar with yoga, review published evidence on this topic, and establish relationships with trained yoga instructors. They could suggest yoga as a gentle exercise option for patients who are inactive or who are interested in increasing their PA; as well as to older adults who need to increase participation in MS or BC activities.

Other strategies include promoting yoga through the health department, and NHS website. The NHS webpage (https://www.nhs.uk/live-well/exercise/guide-to-yoga/) on yoga contains detailed information and could be promoted among internet savvy older adults. In 2018, internet users formed 80% of the population aged 65-74 years and 44% of adults aged 75 years and above (Office for National Statistics, 2018e). Since not all older adults access the internet, it is important to promote yoga through other methods detailed in this section. Targeted yoga classes for specific health issues was discussed at the KE event. Participants felt this may not be practical since the older adult population is characterized by multi-morbidity. It would be better to integrate strategies within the programme to make it accessible to participants with health conditions. A final yoga promotion strategy was to ensure that marketing material is not patronising while targeting older adults.

6.9 Conflicts

The developed yoga programme has some elements that could be thought of as conflicting. The instructor needs to ensure that the programme is progressive and that participants are aware that they are improving and growing in their practice. At the same time, they need to maintain a non-competitive atmosphere. Similarly, the ethos of optimising potential and pushing participants to their own personal edge should go hand-in-hand with a relaxed and non-threatening environment. One possible strategy to achieve this would be providing personalised attention, and the freedom for individuals to grow at their own pace. As mentioned earlier, the instructor should be encouraging and bring attention to small improvements and victories. A participant in Study 2 expressed that people would have different edges for different postures. Participants may be able to perform and advance in some postures easily while other postures may take longer. Postures could be both enjoyable

and challenging and the instructor could handle dualities by focusing on both aspects in a yoga session.

Practicing home-based postures while engaging in other activities such as watching television is another point of conflict. Yoga practice requires focus and awareness. However, performing the postures while engaging in other activities could confer benefits and break up sitting time. Going by the axiom that every bit of PA helps (Department of Health, 2011), participants should be encouraged to perform the home-based exercises at anytime, even if it belies the traditional rules of yoga.

Reduced spiritual and meditative content is another element conflicting with the origins and ultimate goal of yoga. However, we must keep in mind that the programme is being adapted for the western world, where chanting, and other techniques (Shatkarma- cleansing practices, meditative practices), and concepts may be considered culturally unfamiliar. In this regard, it is important to keep sight of programme objectives. Improvements in physical function and psychological parameters can be achieved through physical postures co-ordinated with breathing, as well as incorporating some breathing and relaxation techniques. Yoga is an activity that offers a myriad of benefits, and by reducing spiritual content to increase the appeal of the intervention, the programme focuses on physical and mental benefits. The programme gives a lot of agency to the instructors, and if they judge that the participants would be open to and benefit from meditative techniques and spiritual concepts, they could introduce it at the appropriate stage.

6.10 Gender

Gender was not addressed as a separate theme, but several interventions components within the final intervention aimed to make yoga appealing and acceptable to male older adults. Study 2 participants suggested reducing the spiritual or contemplative aspects of a programme. KE participants felt that ensuring classes are progressive and marking progress would make yoga more appealing to men. Other suggestions to encourage participation among male older adults include

promoting yoga through football/rugby/swimming clubs and gyms, and promoting the benefits of the social aspects of yoga (Study 2). Study 2 and KE participants suggested that having positive role models for men would encourage participation among male older adults. Bringing attention to the benefits of yoga such as help with injuries and improving sporting ability was suggested by KE participants. In Study 3, including pictures of men in the leaflet, and making it clear that yoga was for both men and women was suggested.

Table 24

Components to make the yoga programme less difficult and demanding

Intervention component	Source
Adopt a gentle pace	Study 2 KE event Study 3
Use props and have options for seated exercise	Study 2 KE event Study 3 Bonura (2011) Patel et al. (2011)
Avoid complicated movements	Study 3 Study 2
Ensure that movement between postures is slow and gentle and allow time for rest between postures	Study 2 Bonura (2011)

Table 25

Components to reduce continuous movement between getting up and down from the floor

Intervention component	Source
Avoid continuous movement between standing, and sitting/lying down on the floor. Group the standing and sitting/ lying down postures, so that when participants are standing they're only working on standing postures, and similarly for sitting/ lying down on the floor	Study 3 Study 2 KE event
Letting people know at the start of the session that they will not have to continuously move between standing and getting down on the floor, so they can feel more relaxed during the session	Study 3
Provide instructions on the technique to get up from the floor	Study 3

Table 26

Class content

Intervention component	Source
Class structure:	
Warm up, followed by the main postures including stretches, and ending with cool down and relaxation	Study 1 Study 2
Have longer warm up including repetitive dynamic movements for the shoulders, elbows, wrists, knees and other joints (standing and sitting positions)	KE event Instructor interview from Study 3

Postures and practices to include and avoid:	
Include holding postures	KE event
Use caution during inversions (contraindicated for osteoporosis and glaucoma)	KE event Bonura (2011)
Avoid hot yoga practices (in a heated room) due to potential risk of overheating and stress on cardiovascular function	Bonura (2011)
Avoid jumping into yoga poses or placing excessive pressure on joints through extreme range-of-motion or weight-bearing, leading to strain on the joints	Bonura (2011)
Other inputs:	
Autonomy: A scripted sequence of postures, or a specific yoga style are not provided. Instructors can integrate the principles and guidelines provided with their own practice and style.	Study 3 Instructor interview from Study 3
The programme should be progressive. Establish some method to monitor progress, to make participants aware that they are growing in their practice	Study 2 KE event
Balance between variety and introducing too many new things: variety is important, but introduce limited new postures each week, so that there is something familiar and something new	Study 2 KE event Study 3
Consider the physical activity guidelines and incorporate postures to improve strength and balance. Strength exercises should work all the large muscle groups of the body including upper body muscles	Study 1 Bonura (2011)

Home-based sessions	
If the programme has limited resources and both handouts and videos for home practice cannot be made available to support home-based practice, handouts are preferable as they are more acceptable and accessible to this population	Study 2 KE event Study 3
If the programme consists of class-based sessions and home practice, include exercises in the home-based handout that participants have done before under the supervision of the teacher	Study 2 Study 3
The instructor should ensure that all the postures in the home-based handout are covered during the session, and should highlight the specific postures.	Study 3
A chair was found to be helpful during home-based practice, and postures using a chair could be incorporated	Study 3
Advise participants to choose a stable chair of the appropriate height for home practice	Study 3
Following up (via phone) was one suggested strategy to improve regularity with home-practice	Study 3
Emphasise that practicing yoga at home should not replace aerobic exercise like walking	Study 3
Advise that it's ok to do the postures while doing other activities such as watching television	Study 3
Home-based handouts:	
Keep the handout simple with clear instructions	Study 2 Study 3
Clear instructions on how long to hold postures and number of repetitions	Study 3

Clear instructions on the sequence of exercises including when to do the breathing	Study 3
Provide modification such as removing hand from chair if not challenging enough	Study 3
Intermediate and advanced postures could be introduced at a later stage.	Study 3
Provide some breathing and relaxation exercises	Study 2 Study 3 Patel et al. (2011)
Pictures in the handout should have people in the same age group	Study 2 Study 3
Creating a series of home-based handouts, with progression	Study 3

Table 27

Breathing/spiritual content

Intervention component	**Source**
Older adults felt apprehensive that a yoga programme would have too much spiritual or meditative content, and expressed a preference for limited philosophical/spiritual content. To address this barrier, yoga programmes could include some breathing/meditation/spiritual content but not too much	Study 2 Study 3 Wertman et al. (2016) Patel et al. (2011)

	Humberstone and Cutler-Riddick (2015)
Including breathing practices is important	KE event Bonura (2011)
Breathing could be included at the beginning or at the end of a session	Study 2
Have a relaxation element including the corpse pose is essential	Study 2 KE event Bonura (2011)
Introduce some breathing following the corpse pose before the session ends, so that there is some activation after the corpse pose	Instructor interview from Study 3
Gentle breathing techniques can be included. Breathing practices involving rapid breathing or holding the breath could be contraindicated for older adults or individuals with chronic health conditions.	Bonura (2011)
Breathing during postures is confusing- providing detailed explanation or developing a simple rule of thumb is required. Instructors could convey to participants that it takes time and practice to coordinate breath and movement.	Study 3

Table 28

Guidance for instructors

Intervention component	Source
Asking about health conditions and injuries:	
The instructor should be caring and take an interest in each individual	Study 2
The instructor should ask about health conditions and injuries, and check for impairments such as hearing or sight	Study 2 KE event Study 3 Bonura (2011)
Instructor should offer subtle options for people to disclose any health related or personal issues they may have. Options could include provision to get in touch in advance of the programme or session, meeting before or after classes, or letting instructors know during class	KE event Instructor interview from Study 3
For people with impairments, instructor should ask them what would be helpful and what could be done to help them participate comfortably.	KE event
Instructor should enquire about how participants are feeling, if they're alright or need any help	Study 2 Study 3 Instructor interview from Study 3

Set expectations with participants, as the benefits of yoga may be long-term	KE event
Creating a non-competitive environment and reducing embarrassment:	
Instructor should convey that participants can take it at their own pace during the session and participants should not feel that they're forced to perform postures. Participants should be given the option of not doing certain postures or movements	Study 2 KE event Study 3
Participants should be encouraged to adopt a "non-violent approach" where they don't force themselves in postures- this is mentioned in the beginning of the class, and participants should also be reminded during the session, before a posture and while holding the posture	Instructor interview from Study 3
Awareness and mindfulness: participants should be encouraged to be aware of their bodies and limitations. Being mindful during a yoga session would ensure that they don't strain, reducing the risk of injury	Based on yoga expertise of author
Encourage participants to be in the moment and feel the movements of the body synchronised with the breath	Humberstone and Cutler-Riddick (2015)
Don't make the class competitive or goal oriented. Instead of aiming for a "perfect" yoga posture, focus on safe postures and improving health outcomes	KE event Bonura (2011) Humberstone and Cutler-Riddick (2015)
Don't make assumptions about prior knowledge of yoga or physical capability of participants	KE event
Offer personalised encouragement and feedback, but without spotlighting people	KE event

Encourage participants to take breaks where needed, even during a pose	Bonura (2011)
Understanding older adults:	
Understanding older adults and the physiology of ageing	Study 2 KE event
Instructor should recognise that older adults may have mobility limitations	Study 2 Study 3
Participants should be provided the space and encouragement to reflect on their bodies and ageing during yoga practice	Humberstone and Cutler-Riddick (2015)
Instructor should be aware of the level of each person in the class and their abilities	Study 2
Important qualities in an instructor include being sympathetic, approachable, patient, encouraging, and being sensitive to the needs of older adult participants	Study 2 Humberstone and Cutler-Riddick (2015)
Providing positive images and examples of older adults	Humberstone and Cutler-Riddick (2015)
Challenge but not pain:	
Instructor must aim to push participants to their "personal edge" with the ethos of optimising potential	Study 2 KE event
Instructor should strive to achieve the balance between challenging and pushing participants but at the same time allowing them to take things at their own pace with no pressure	Study 2

Pain and strain are not appropriate. When discomfort is experienced, the instructor should bring down the level of exertion, and advice participants not to do anything that does not feel right	KE event Bonura (2011)
If discomfort continues, the instructor should advise that the individual stops and consults a doctor prior to further yoga practice	Bonura (2011)
Offering posture modifications:	
Instructor should offer alternative postures, providing easier options, using props if required	Study 2 KE event Humberstone and Cutler-Riddick (2015)
Adopt a multi-level approach to demonstrating postures- starting with the simplest pose, and then progressing to more advanced variations (rather than starting with the complicated version and offering modifications)	Instructor interview from Study 3 Bonura (2011)
Instructor should have a knowledge of common health conditions among the older population, be familiar with adaptations of postures, and which postures are contraindicated	KE event
If participants struggle with a pose, and no posture modifications are possible, they should be advised to completely avoid the posture	Instructor interview from Study 3
Demonstrating:	
It is important for instructors to demonstrate	Study 2 KE event

Instructor should demonstrate using different planes and angles (view from front, and then side)	Study 3
One suggested strategy is to demonstrate a simple version to be performed during the session, and also the most advanced version, so that participants understand the movement and know what they're aiming for. However, instructors should avoid demonstrating unnecessary advanced postures.	KE event Study 3 Instructor interview from Study 3
It is important to mirror the audience while demonstrating- face the audience and demonstrate on your left side, while the participants do the same movement on the right side	Study 3 Bonura (2011)
It's helpful if participants could first watch the instructor's demonstration and then follow, as they may find it difficult to watch and follow at the same time	Study 2
If the instructor is much younger, they could ask older students to demonstrate	KE event
Communication:	
Although a programme brief is provided, it is important for instructors to integrate the programme with their own style, so that it flows naturally	Study 3
The instructor should have a good communication style and create good rapport with participants	Study 2 KE event
The instructor should be audible, speak clearly and repeat instructions if required	Study 2 KE event
The instructor should give clear instructions, with explicit directions for each body part	Study 2 KE event

The instructor should determine participant's level of comfort with Sanskrit (classical Indian language) or Eastern influences, and adapt the yoga class format and language as appropriate. Using jargon should be avoided	Bonura (2011) KE event
The instructor should be sensitive to judgmental instruction, and avoid negative and age-related language. It is important to use positive and encouraging words, and focus on what they can do rather than limitations.	KE event Bonura (2011)
Instructors could provide explanation during the session. For example, the part of the body that is being worked on, tips on breathing/balance	Study 3
Instructors could make connections between yoga and daily life, stressing the functional benefits	KE event
Correcting postures:	
Don't assume people want to be adjusted into more advanced positions	KE event
Instructor should move around the class and correct and adjust postures. However, they should abstain from manually correcting the postures and focus on verbal correction	Study 3 Study 2 Bonura (2011)
Instructors training and knowledge	
Training and experience of a yoga teacher is important	KE event Study 2 Bonura (2011)

Training for instructors on the appropriate modifications for some key problem areas and health conditions (example: knees, difficulties in reclining) in older adults would reduce pain and discomfort in postures and ensure programme is accessible to participants with health conditions	Study 3 Nayak et al. (2015)
Training for instructors is also required on the muscle strengthening postures for each major muscle group and progression for each posture- introductory, intermediate and advanced versions of postures	Recommendation based on PhD findings
Training on the physiology of ageing, and physical activity guidelines for older adults should be imparted to instructors	Study 2 KE event Recommendation based on PhD findings
Instructor should stay abreast with the latest yoga research evidence	Bonura (2011)

Table 29

Components to encourage social interaction

Intervention component	**Source**
The programme should offer post class social options to create better relationships with students, and provide them an opportunity for social interaction	Study 2 KE event Wertman et al. (2016)
It is important to allow time for student interaction before, after, and during class (if appropriate) to support students who come to class for social interaction	Bonura (2011)

Table 30

Class details

Intervention component	Source
Class environment:	
The room should be warm but not too hot- the temperature should be comfortable	KE event Instructor interview from Study 3
The room should be made welcoming (warm, draught free, clean, good lighting)	KE event
Props like stable chairs, mats and blocks should be available	Study 2 KE event Study 3 Instructor interview from Study 3 Bonura (2011)
Mats should be arranged to ensure that all participants have enough space without infringing on other's personal space. There should be enough space to stretch arms out.	Study 3 Study 2
It is important to choose a quiet location, and avoid background music out of consideration for students who may have hearing difficulties	KE event Bonura (2011)
Incense or candles should be avoided out of consideration for students who may have breathing conditions such as chronic obstructive pulmonary disease	Bonura (2011)
Attire:	
Instructions should be provided on appropriate clothing and shoes	Study 2 Study 3

Students should be allowed to leave shoes on during the yoga session in case of foot conditions, balance issues, or physical/psychological discomfort with being barefoot	Bonura (2011)
Participants should also be warned that performing postures with just socks could lead to reduced stability and increased risk of slipping.	Study 3
Class size:	
Smaller class size of about 10-20 participants is preferable, but not too small	Study 2 KE event Study 3
Participants should be able to see and hear the teacher	Study 2
While one instructor is sufficient for smaller classes, 2-3 assistants may be required for larger classes, with one instructor demonstrating, and others walking around and correcting postures	KE event Instructor interview from Study 3
Duration and frequency for class-based sessions:	
Lack of time and class too long were identified as barriers, and shorter classes may be one strategy to overcome this	KE event Nayak et al. (2015) Wertman et al. (2016)
Average duration of a class may be 60 minutes, with activity for approximately 50 minutes, especially if participants are new to yoga	Study 1 Study 2
For regular practitioners, sessions of more than one hour may be appropriate (75 or 90 minutes)	Study 2
The preferred frequency is once or twice a week	Study 1 Study 2

Duration and frequency for home-based sessions:	
Two days a week of home-based practice is acceptable to participants	Study 3
Shorter session (10-15 mins)	Study 2 Study 3
Age group and level:	
Preference to attend classes with people of the same age group or level	Study 2 Study 3
Classes should consider the stage/fitness levels of the participants and not always the age	KE event
It is advisable to have different levels of classes and not lump everyone together	KE event
Gender of instructor:	
Gender of instructor does not affect participation	Study 3

Table 31

Yoga promotion strategies

Intervention component	Source
Taster session	
Taster sessions can be introduced as a strategy to provide information and address negative perceptions of yoga	Study 2 Study 3
All relevant intervention components such as guidance for instructors and class content can be incorporated within the taster session	Study 3

Taster session duration could be 30-40 minutes	Study 3
Leaflet	
Leaflet content:	
Clarity is important, providing useful information without being over-loaded	Study 3
Leaflet should not be too patronising or over-simplified	Study 3
Mentioning the enjoyment aspect was appreciated	Study 3
It needs to be clear in the leaflet that yoga is for both genders	Study 3 Study 2
Provide information on available yoga classes with contact information and website	Study 3
Information on the types of yoga that would be suitable for older adults would be useful	Study 3
If the leaflet is used to promote a specific yoga programme, add information about the programme being promoted, and how it's is geared for an older adult population, even mentioning that it is not about contortions	KE event Study 3
Include NHS website (https://www.nhs.uk/live-well/exercise/guide-to-yoga/)	KE event Recommendation based on PhD findings
Leaflet- information on benefits of yoga:	
Provide information on the benefits of yoga, especially brain function	Study 3 Study 2 KE event Patel et al. (2011) Humberstone and Cutler-Riddick (2015)

Mentioning benefits of yoga such as helping with injuries and improvement in sporting ability could make yoga more attractive to male older adults	KE event
Suggestion that prevention of falls should be included as a benefit of yoga.	Study 3
Leaflet- information on social interaction:	
Mention opportunities for social interaction	Study 3 Study 2
Leaflet- examples of strategies to reduce feelings of embarrassment, and convey that yoga classes have a non-threatening and non-competitive environment:	
Mention that you could do yoga to whatever extent suits you (For example, as a quote)	Study 3 Study 2
Mention that yoga can be done by everyone	Study 3
Leaflet- design layout and colours:	
Colourful and eye-catching designs are appreciated	Study 3
Ensure font size is easy to read	Study 3
If it's meant to be a leaflet they can take away, a foldable booklet was suggested. A poster (A3 or A4) may be too big to fit into a handbag, and would be bulky to take away.	Study 3
Leaflet- language and wording:	
Use a variety of positive words	Study 3
Use simple language with no jargon	Study 3 KE event

Leaflet- comments on pictures:	
Realistic pictures that are reassuring and not too challenging with no contortions should be used	Study 3 Study 2 KE event
Feature people that older adults can identify with	Study 3
Avoid pictures of people in posh yoga clothes	Study 3
Having a chair in the pictures was found to be reassuring	Study 3
Pictures of exercises that look too intense and those that look too simple could put off people. Strike the right balance	Study 3
Include both men and women in the pictures	Study 3
Home-based handouts	
Home-based handouts could be used to provide those who are new to yoga with an idea of what to expect in a yoga class, addressing the barrier of lack of information and encouraging participation	Study 3
Other strategies to promote yoga	
Offering short summer yoga courses (around 6 classes)	Study 3
Promoting and incorporating some yoga in other exercise classes and activities	Study 2 KE event
People who do yoga encourage friends and partners to participate	Study 2 KE event

	Wertman et al. (2016) Nayak et al. (2015)
Promoting yoga through pre-retirement courses and charities	Study 2 KE event
Showing informative videos and conducting info-demonstrations	KE event
Nomenclature: While there are positive and negative arguments to calling the programme “yoga”, one strategy suggested was to add a tag line to “yoga” that would elaborate on who it's for, what it is, and the benefits	Study 2
Positive role models and role models for men	Study 2 KE event
Promoting yoga in football/rugby/swimming clubs and gyms to encourage yoga participation among male older adults	Study 2 KE event
Promoting yoga medically and through healthcare professionals and physiotherapists	Study 2 KE event
Working with medical practitioners, to take into account medical history and determining specific yoga postures that are inappropriate for the patient’s personal health profile. Getting health professionals more involved in demonstrations and taster sessions	KE event Bonura (2011)
Encouraging healthcare professionals to become familiar with yoga. They could also review published literature and be informed of the benefits of yoga	Bonura (2011)
Encouraging healthcare professionals to establish relationships with trained yoga instructors who have experience in working with older adults	Bonura (2011)

Healthcare professionals could suggest yoga as a gentle exercise option for patients who have not been active or who are interested in increasing their physical activity; as well as to older adults who need to increase participation in MS or BC activities	Recommendation based on PhD findings Bonura (2011)
Yoga could be promoted by the health department	KE event
Promoting yoga via the NHS website (https://www.nhs.uk/live-well/exercise/guide-to-yoga/)	KE event
Targeted yoga classes for health issues have been discussed but may not be practical since the older adult population is characterized by multi-morbidity	KE event
It is important not to adopt a patronizing tone when marketing to the older adult population	KE event

Chapter 7. Theory of Change

This chapter aims at understanding how the final yoga programme would work, and the mechanisms by which the programme would achieve outcomes such as increased adherence to MS and BC guidelines and improved physical function and HRQoL. A background to developing a theory of change model for the final yoga intervention was provided in Chapter 2. An initial model was presented and the methodology for further developing the theory of change models was described in detail. This chapter details the results of the development process, and the final theory of change model for the developed yoga programme. The development process included situation analysis, focus and scoping, and developing an outcome chain.

7.1 Situation Analysis

The main focus of this analysis was an exploration of the causes of inactivity

7.1.1 Causes of inactivity. Bauman et al. (2012) emphasised that an understanding of why people are active or inactive is essential to improve intervention development. Several study designs have been employed to understand the mechanisms underlying PA participation, from which parameters such as correlates, determinants, motivators and barriers have emerged. Since these terms have often been used incorrectly in literature with "determinants" used to describe terms that are actually "correlates" (Bauman, Sallis, Dzewaltowski, & Owen, 2002), a clarification on the definition of these terms in the context of PA is presented:

(i) Correlates. These are factors associated with inactivity. Studies examining correlates usually employ cross-sectional designs. They assess the statistical association between factors and PA (Bauman et al., 2012; Bauman et al., 2002). For example, the strength of association between the built environment and PA in South African older adults was assessed in a pilot study using a cross-sectional study design (Kolbe-Alexander, Pacheco, Tomaz, Karpul, & Lambert, 2015). "Neighbourhood aesthetics" was found to be positively associated with leisure-time PA, and can be considered a correlate of older adults PA participation. However,

factors identified as correlates are limited in that they do not provide evidence of a causal relationship between two variables.

(ii) Determinants. These are defined as causal factors, identified using longitudinal observational, and experimental study designs. A causal relationship would indicate that a variation in these factors is followed by variations in PA behaviour (Bauman et al., 2012; Bauman et al., 2002). For example, a study with a prospective design investigated whether social-cognitive factors predicted long-term PA in an older adult sample (McAuley et al., 2007). The study reported that individuals with higher self-efficacy were more likely to be active. In this study, self-efficacy can be considered a determinant of exercise participation in older adults.

In their paper, Bauman et al. (2002) also mentioned other important factors that should be considered while assessing causality, drawing from the Bradford Hill criteria (Fedak, Bernal, Capshaw, & Gross, 2015)-

(i) Strength and consistency of association: larger associations which are consistent when replicated are more likely to be causal.
(ii) Temporality: exposure to the factors must precede outcome for the relationship to be causal.
(iii) Dose response: if a dose response relationship is evident, the association is likely to be causal.
(iv) Plausible: the causal relationship should be plausible.

(iii) Motivators and barriers from qualitative studies. Researchers are also interested in descriptive and contextual reasons for PA involvement. This can be captured by qualitative studies using interviews, focus groups, and other self-reported data. Studies with quantitative designs like surveys have also established motivators and barriers. However, for the purpose of this analysis, factors from studies that have established a statistical association will be classified as correlates, and only those from qualitative studies will be classified as motivators or barriers. Motives can be defined as stated reasons for involvement in PA, and barriers are factors that would discourage or prevent participation (Biddle et al., 2015).

Depending on the study design, a factor can be classified as a correlate, determinant or motivator/barrier by different studies.

In this section, key correlates, determinants, motivators and barriers to PA participation in older adults have been identified and assimilated using an ecological model. The ecological model posits that behaviour has multiple and interacting levels of influences, including intrapersonal (biological, psychological), interpersonal (social, cultural), organizational, community, physical environmental, and policy (Sallis, Owen, & Fisher, 2008). Figure 37 is an adapted ecological model framework for the factors affecting PA participation (Bauman et al., 2012). Based on this, correlates, determinants, motivators and barriers have been classified and discussed under the following headings: individual (demographic, biological/health, psychosocial, other), socio-cultural and environmental/community factors.

Figure 37. An adapted ecological model framework for the correlates, determinants, motivators and barriers of physical activity. Adapted from "Correlates of physical activity: why are some people physically active and others not?" by Bauman et al., 2012, *The lancet, 380(9838), 258-271*. Copyright [2012] by Elsevier Ltd. Reprinted with permission.

The determinants, correlates, motivators and barriers to PA participation in older adults were compiled from existing systematic reviews. The systematic reviews included in this analysis were identified through a Medline search which included the intersection of the following terms limited to review articles: a) terms dealing with older adults such as old, aged, aging, elder b) terms relating to physical activity, physical inactivity or exercise c) determinants or correlates or motivators or barriers (all search terms provided as a supplementary file- Appendix 40). One hundred and twenty-one records were identified for determinants, 51 records for correlates and 75

for motivators and barriers. These records were manually screened and relevant systematic reviews (describing correlates, determinants, motivators/barriers to PA in an older adult population) were selected. To get a comprehensive understanding of the causes of inactivity, all factors (including individual, social/cultural and environmental) were included in the analysis, from which modifiable factors were selected in the next stage of analysis. The systematic reviews identified from these searches gives us an idea of the salient determinants, correlates, motivators and barriers to PA participation in older adults. It is however not an exhaustive list as it is the product of a thorough but not systematic literature search. The following systematic reviews were included in the analysis:

1. Koeneman, Verheijden, Chinapaw, and Hopman-Rock (2011) systematically reviewed determinants of PA and exercise (EX) in healthy older adults. They included prospective studies (observational, intervention and RCTs) reporting determinants of PA or EX in healthy older adults defined as aged 55 years and over. The review reported determinants of PA, EX, or a combination of the two. For the purposes of this analysis, all of these have been recorded under determinants of physical activity. Evidence of relationship between determinants and PA, EX or PA/EX was rated as:
   (i) Strong: consistent (at least 75% of the studies showing significant results in the same direction) findings in two or more high methodological quality studies
   (ii) Moderate: consistent findings in one high quality and at least one low methodological quality studies, or consistent findings in multiple two or more low methodological quality studies
   (iii) Insufficient: only one study available or inconsistent findings in multiple two or more studies

2. Notthoff, Reisch, and Gerstorf (2017) conducted a systematic review to identify individual characteristics that are consistently linked to high PA levels in adults aged 60 years and over. The systematic review did not include intervention studies, but included studies that reported a quantitative association between PA and demographic characteristics (gender, education,

marital status, employment), health (subjective, health problems), and psychological factors (motivation, self-efficacy, locus of control). The characteristics will be classified as correlates based on the definitions followed in this analysis. The outcome variable in the systematic review was PA recorded under different domains like sports/exercise, walking, PA in the house or garden, vigorous PA, work-related PA, PA for transportation, leisure-time PA, total PA, meeting PA guidelines, and any type of PA which encompassed all of the domains. For this analysis individual characteristics related to any type of PA were considered.

3. Barnett et al. (2017) conducted a systematic review and meta-analysis of built environmental correlates of total PA in older adults aged 65 years and over. The review included studies with a cross-sectional, longitudinal or quasi-experimental design. Total walking and total PA were the outcomes in the study, but only total PA was considered in this analysis.

4. A systematic review of the barriers and motivators for PA participation in adults aged 80 and over was conducted by Baert, Gorus, Mets, Geerts, and Bautmans (2011). They found 15 publications with a qualitative design and 29 with a quantitative study design. Since the study does not report results separately for quantitative and qualitative papers, results have been captured as motivators and barriers for this review. The review identified 61 barriers and 59 motivators, but in this analysis only factors reported by three or more variables have been included to restrict included factors and focus on the ones reported consistently in studies.

5. Moran et al. (2014) systematically reviewed qualitative studies to understand the impact of the physical environment on older adult's PA behaviours. Five environmental themes with subthemes emerged from the data including: (1) pedestrian infrastructure, (2) safety, (3) access to facilities, (4) aesthetics, and (5) environmental conditions. Themes and subthemes were interpreted as a barrier or motivator for this analysis.

6. Franco et al. (2015) systematically reviewed qualitative studies to identify barriers and facilitators to PA participation in older adults aged 60 years and over. They used thematic synthesis to analyse data, and identified six major themes: social influences, physical limitations, competing priorities, access difficulties, personal benefits of PA, and motivation and beliefs. Themes and subthemes were classified as motivators or barriers for this analysis.

Before discussing the evidence on determinants, correlates, motivators and barriers relating to PA participation in older adults, it is important to note that this evidence base (as reflected in these selected systematic reviews) has several limitations.

7.1.1.1 Limitations

(i) Methods to assess associations. Notthoff et al (2017) used a vote-counting approach (Bushman & Wang, 2009) where a score of "+" was assigned when the association between the examined individual characteristic and PA was positive, a score of "–" when the association was negative, and a score of "0" when no association was detected. Vote counting has been criticised as sample size and effect size of individual studies are not properly incorporated in the decision making process. However, it provides an indication of factors consistently associated with PA levels.

(ii) Inadequate reporting of variables. Another limitation is that PA and EX have been used interchangeably in many studies included in the systematic reviews encompassed in this analysis (Baert et al., 2011). As a result, in the present analysis it was not possible to distinguish determinants of PA or EX, and these were combined into one category. Lack of clear and consistent definitions in reviews as well as individual studies included in these reviews is another limitation. The terms motivators and barriers were not clearly defined in the study by Baert et al. (2011) which included both qualitative and qualitative studies, with little information on how results from varying study designs were pooled together. Moreover, within

several reviews some identified motivators and barriers were not clearly defined and are left to interpretation such as “too tired” or “pain reduction” (Baert et al., 2011). One possible reason for this could be that the included papers did not provide any explanation for these terms. Another example is self-efficacy, where self-efficacy through PA was reported by Baert et al. (2011), EX self-efficacy was reported by Koeneman et al. (2011), and just self-efficacy was reported by Notthoff et al.(2017).

(iii) Quality of individual studies. The quality of included studies varied in the reviews. A lack of high quality studies was reported by Koeneman et al. (2011). Varying comprehensiveness of reporting (Franco et al., 2015), and varying quality scores (Notthoff et al., 2017) among included studies were reported. Baert et al. (2011) reported very good theoretical approach and appropriate qualitative approach in included studies. No assessment of quality was provided by Moran et al. (2014).

Despite these limitations, the systematic reviews provide a relatively comprehensive overview of the potential factors which influence PA in older adults. These are summarised in Table 32 and described below.

7.1.1.2 Individual- demographic factors

Determinants. Koeneman et al. (2011) found moderate evidence for an association between gender and PA, with males more likely to participate in PA. Moderate evidence was also found for a positive association between younger age (within an older adults classification) and PA.

Correlates. In the systematic review by Notthoff et al. (2017), across all PA types, men were found to be more active than women in 27 instances and less active in 7; no association between gender and PA level was found in 19 instances. Although the authors reported that results are inconclusive, gender has been included as a correlate as the number of studies showing a significant association was more than the number showing no association. Similarly, education was also included as a correlate as across all PA types, higher levels of education

was associated with increased PA participation in 21 instances, and in 17 instances, there was no association between education and PA.

7.1.1.3 Individual- biological and health variables

Determinants. In the review by Koeneman et al. (2011), moderate evidence was found for a positive association between general physical functioning and EX. Moderate evidence was found for a negative association between chronic conditions/diseases and EX, and for a negative association between BMI and PA/EX.

Motivators and barriers. The following factors were found to be motivators for physical activity participation in the review by Baert et al. (2011): Weight control, fitness incentive, maintaining an active lifestyle, and PA helping to reduce or relieve pain. Health conditions, increased pain and feeling too tired were barriers to PA participation.

In the review by Franco et al. (2015), physical limitations caused by existing comorbidities was reported as a barrier to PA. On the other hand, helping to control chronic conditions and cope with or relieve pain was seen as a motivator to participating in PA.

7.1.1.4 Individual- psychosocial variables

Determinants. Koeneman et al. (2011) found moderate evidence for a positive association between change in EX self-efficacy and EX. Moderate evidence was found for a negative association between depression and EX.

Correlates. Across all PA types, Notthoff et al. (2017) reported a positive association between subjective health and PA participation in 19 studies and no association in 8 studies. Higher levels of motivation were associated with higher PA levels in two instances. Higher self-efficacy was associated with more PA in 7 instances, and no association was found in one instance.

Barriers and motivators. Baert et al. (2011) reported that improved health status, and self-efficacy were motivators to PA participation. Lack of motivation, laziness, depressive symptoms/depression, embarrassment and feeling self-conscious were reported as barriers.

Franco et al. (2015) found that lack of motivation, laziness, being self-conscious in a group of younger people, feeling intimidated that they can't keep up with those at a more advanced level were barriers to participation. Improved self-confidence and being able to maintain their independence were motivators to participation.

7.1.1.5 Individual- psychosocial- attitudes to PA

Determinants. Koeneman et al. (2011) reported that there was moderate evidence for a positive association of self-reported beneficial health or physical functioning outcomes with EX.

Motivators and barriers. Baert et al. (2011) reported knowing the benefits of PA, experiencing the health, physical functioning and psychological benefits of PA, enjoyment and pleasure from PA participation and less perceived stress through PA as motivators for participating in PA. No knowledge about EX, disliking PA, fear of falls and injuries or pain were barriers to participation.

Pain and discomfort during PA and high PA intensities were found to be barriers to PA in the review by Franco et al. (2015). Disinterest, a belief that exercise was unnecessary, irrelevant, inefficacious for older adults, and that it may even be harmful were barriers. Fear of falls was another identified barrier. Knowledge about some benefits of PA such as improvements in MS, balance, mobility, flexibility, health, mental wellbeing and prevention of falls was a motivator to PA participation.

7.1.1.6 Individual- other variables

Determinants. Moderate evidence for a positive association between prior exercise adherence and EX was found, and between baseline activity and PA/EX in

the review by Koeneman et al. (2011). Moderate evidence was also found for a negative association between major life events and EX.

Motivators and barriers. Cost and lack of time were reported as barriers; and positive past experiences with PA was a motivator for PA participation in the review by Baert et al. (2011).

Franco et al. (2015) found that cost was a barrier to participation. Those who have always been physically active remained active at an older age, and those who have been inactive showed reluctance to start exercising as they aged.

7.1.1.7 Social and cultural factors

Motivators and barriers. In the review by *Baert et al.* (2011), no exercise companion or being alone, having to take care of siblings or others and competing commitments were barriers to PA participation. Social interaction and social support were reported as motivators.

Competing commitments was found to be a barrier to participation in the review by Franco et al. (2015). Social interaction and social support were found to motivate older adults to be physically active. Cultural sensitivity to ethnic minorities was also a motivator to participation.

7.1.1.8 Environmental factors

Correlates. The systematic review and meta-analysis by Barnett et al. (2017) reported significant positive associations between PA and the following environmental factors (ranked by strength of evidence): walkability, safety from crime, overall access to destinations and services, recreational facilities, parks/public open space, shops/commercial destinations, greenery and aesthetically pleasing scenery, walk-friendly infrastructure, and access to public transport.

Barriers and motivators. Some barriers to PA cited in the systematic review by Moran et al. (2014) were the lack of pedestrian infrastructure, crime and traffic

related safety. Lack of access to recreational facilities, senior group activities, green open spaces, daily destinations like shops, public transport, rest areas like benches and public washrooms were also mentioned as barriers. Aesthetically pleasing landscapes and natural scenery would aid PA participation. Bad weather and pollution were mentioned as barriers to activity.

In the review by Baert et al. (2011), neighbourhood safety, lack of access to exercise facilities and transport facilities, character of the programme and bad weather were barriers to PA participation.

The following barriers were identified by Franco et al. (2015); lack of pedestrian infrastructure, neighbourhood safety, transport, facilities, benches for resting, unavailability of exercise programmes and bad weather. Motivators were presence or quality of instructor. Exercise without an instructor was viewed as unsafe. Programmes tailored to participant's capabilities and needs were appreciated. Attractive scenery was also a motivator to PA participation.

Table 32

Correlates, motivators and barriers to physical activity in older adults

	Koeneman et al. (2011)	**Notthoff et al. (2017)**	**Barnett et al. (2017)**	**Baert et al. (2011)**	**Moran et al. (2014)**	**Franco et al. (2015)**
Age in studies	>= 55 years	>=60 years	>=65 years	>79 years	>= 65 years	>= 60 years
Study design	Systematic review of prospective studies (observational, intervention and RCT)	Systematic review of studies that reported a quantitative association between PA and demographic, health and psychological factors	Systematic review of studies with a cross-sectional, longitudinal or quasi-experimental design	Systematic review of quantitative and qualitative studies reporting motivators and barriers for PA	Systematic review of qualitative studies exploring the impact of the physical environment on PA behaviours	Systematic review of qualitative studies
Individual						
Individual - Demographic variables						
Age	Determinant PA (-)					
Education		Correlate (+)				
Sex	Determinant PA - male (+)	Correlate- male (+)				
Individual- Biological and health variables						
BMI	Determinant PA/EX (-)					
Weight control				Motivator		
Fitness incentive				Motivator		
To maintain an active lifestyle				Motivator		

Health conditions/illness	Determinant EX (-)			Barrier		Barrier
To control chronic conditions						Motivator
Helps reduce/cope with or relieve pain				Motivator		Motivator
Increased pain				Barrier		
General physical function	Determinant EX (+)					
Too tired				Barrier		
Individual - Psychosocial variables						
Subjective health/Health status		Correlate (+)		Motivator (improved health status)		
Motivation		Correlate (+)		Barrier (lack of)		Barrier (lack of)
Laziness				Barrier		Barrier
Self-efficacy	Determinant EX (+)	Correlate (+)		Motivator		
Self-esteem and self-confidence						Motivator
Independence						Motivator
Depressive symptoms/ depression	Determinant EX (-)			Barrier		
Self-conscious/embarrassed/ intimidation/feel they can't keep up				Barrier		Barrier
Self-conscious in a group of younger people or people at a more advanced level						Barrier

Individual-Psychosocial-Attitudes to PA						
No knowledge about exercise				Barrier		
Knowing the benefits of PA				Motivator		Motivator
Experiencing the health or physical functioning benefits of PA	Determinant EX (+)			Motivator		
Experiencing the psychological health benefit of PA				Motivator		Motivator
Dislike/disinterest PA				Barrier		Barrier
Irrelevance and inefficacy						Barrier
Enjoyment/pleasure through PA				Motivator		
Pain and discomfort during PA						Barrier
Fear of falls				Barrier		Barrier
Fear of injury or pain/ harm				Barrier		Barrier
High intensity PA						Barrier
Less perceived stress through PA				Motivator		
Individual -other variables						
PA participation/Prior exercise adherence	Determinant EX (+)					Motivator
Baseline PA	Determinant PA/EX (+)					
Positive past experience with PA				Motivator		

Cost				Barrier		Barrier
Lack of time				Barrier		
Major life events	Determinant EX (-)					
Social and cultural variables						
No exercise companion/being alone				Barrier		
Social interaction				Motivator		Motivator
Social support				Motivator		Motivator
Care of siblings/others				Barrier		
Competing commitments				Barrier		Barrier
Cultural sensitivity with ethnic minorities						Motivator
Environmental/community factors						
Walkability/pedestrian infrastructure			Correlate (+)		Barrier (lack of)	Barrier (lack of)
Safety from crime/Neighbourhood safety			Correlate (+)	Barrier	Barrier (lack of)	Barrier (lack of)
Traffic related safety					Barrier (lack of)	
Overall access to destinations and services			Correlate (+)			
Access to recreational facilities /exercise programmes			Correlate (+)	Barrier (lack of)	Barrier (lack of)	Barrier (lack of)
Access to senior group activities					Barrier (lack of)	

Presence and quality of exercise instructor						Motivator Lack of was seen as unsafe
Character of the programme				Barrier		
Programme tailored to participants capability						Motivator
Parks/public open space			Correlate (+)		Barrier (lack of)	
Access to shops/commercial destinations			Correlate (+)		Barrier (lack of)	
Greenery and aesthetically pleasing scenery			Correlate (+)		Motivator	Motivator
Walk-friendly infrastructure			Correlate (+)			
access to public transport / transport facilities			Correlate (+)	Barrier	Barrier (lack of)	Barrier (lack of)
Access to rest areas and public washrooms					Barrier (lack of)	Barrier (lack of)
Bad weather				Barrier	Barrier	Barrier
Pollution					Barrier	

Compiling the exhaustive list of motivators and barriers to physical activity was an important stage in the development of the theory of change for the final yoga intervention. The next steps involved identifying modifiable factors, and mapping intervention components to the motivators and barriers they would address.

7.2 Focus and Scoping

The factors affecting physical inactivity were listed, from which the ones that the yoga programme would address were identified. The Fishbone diagram (Figure 38) comprises all the factors associated with inactivity categorised as i) to be addressed by the programme or ii) out of scope.

Figure 38. Fishbone diagram summarizing determinants, correlates, motivators and barriers to physical activity participation in older adults

7.3 Outcome Chain

An outcome chain was developed linking activities to outputs, intermediate and final outcomes. Previous literature, inputs from the target population and instructors were used to develop the outcome chain. The final outcomes in the outcome chain reflect the main goals of the programme, and include increased participation in strength and balance activities, and, improved physical function and HRQoL outcomes in older adults. However, during the process of developing the theory of change, another potential outcome was identified which is breaking up of sedentary behaviour (SB). SB has emerged as a new risk factor for health, distinct from insufficient physical activity (Owen, Healy, Matthews, & Dunstan, 2010; Rezende, Rey-López, Matsudo, & Luiz, 2014). SB has been described as any waking activity in a sitting or reclining posture with energy expenditure less than or equal to 1.5 MET (Sedentary Behaviour Research Network, 2012). Common SBs include television viewing, video game playing, computer use , driving automobiles, and reading (Sedentary Behaviour Research Network, 2012). Greater sedentary time has been linked to an increased risk of all-cause mortality in older adults (Rezende et al., 2014), and was found to be consistently associated with worse cardiac lipid profiles and increased cardiac risk scores (Hajduk & Chaudhry, 2016). Research evidence also shows that SB is associated with cardiometabolic risk factors independent of MVPA (Gennuso, Gangnon, Matthews, Thraen-Borowski, & Colbert, 2013). Hence, it is important that in addition to increasing PA, older adults also reduce SB (Department of Health, 2011).

7.4 Theory of Change for the Final Yoga Programme

Although only one initial theory of change model was presented, during the development process it became clear that there were two distinct goals, one was to increase recruitment and participation in a yoga programme, and the other was to increase adherence to a yoga programme. This aligns with the two main objectives of this PhD. Accordingly, two theory of change models have been developed. Theory of change 1 examines how the programme components would lead to increased participation or recruitment to a yoga programme and deals with promotional strategies (Figure 39). Theory of change 2 (Figure 40) examines how the programme

components would achieve adherence to a yoga programme or retention.

7.4.1 Theory of change 1. Theory of change 1 (Figure 39) addresses strategies to promote yoga. Resources and inputs include programme developers such as researchers, studios, instructors liaising with pre-retirement courses and charities, existing yoga practitioners, healthcare professionals and government health departments. The yoga promotion activities are described in detail as a part of the final intervention (Tables 26). All activities would lead to increased awareness about yoga, and help achieve the main intermediate outcome of increased participation/recruitment of older adults to a yoga programme. Providing home-based handouts is an activity that would create opportunities for home-based exercise. In addition to encouraging home-based practice, these would also increase participation among those who cannot attend a class-based session. A final outcome that only this specific activity leads to is breaking up of SB.

Suggestions with respect to nomenclature would enhance the appeal of the name of the programme among potential participants, which would encourage recruitment and participation in yoga. Working with healthcare professionals would dispel apprehensions that older adults have about yoga such as “will hurt” or “will worsen health issues” (Nayak et al., 2015). Healthcare professionals could encourage older adults with health conditions and impairments to take up yoga. This would help reach older adults who may be inactive or have health conditions and impairments. Having positive role models, and promoting yoga through football/rugby/swimming clubs and gyms were specifically recommended as strategies to encourage male older adults to participate in yoga. In the leaflet, mentioning benefits like helping with injuries and improving in sporting ability, and including pictures of men would increase the appeal of yoga to a male audience. The final outcomes for Theory of change 1 are increased participation in an activity that would increase adherence to strength and balance guidelines, which would lead to improved physical function and HRQoL outcomes.

7.4.2 Theory of change 2. In Theory of change 2 (Figure 40), the resources and inputs can be divided into two categories with corresponding activities- i)

Programme developers, researchers, studios and instructors: activities include intervention components pertaining to the yoga session such as class content and details, opportunities for social interaction, and training of instructors. These activities result in the creation of a programme that is appealing, acceptable and appropriate for older adults. Ensuring that the programme is progressive, and considers MS and BC guidelines would lead to the creation of a programme that is geared towards improving strength and balance outcomes in older adults. Moreover, including an optimal amount of spiritual content and having a progressive programme would address the gender bias and enhance the acceptability of the programme among male older adults. Providing guidance and training to instructors would help them deliver the programme effectively, and would also provide them with the skills to work with older adults who have impairments and health conditions. ii) Instructors: activities include guidance for instructors to be followed while working with older adults. All of these actives result in the creation of a programme that is appealing, acceptable and appropriate for older adults. The instructor taking efforts to understand the physiology of ageing, catering to the level of the class, and offering posture modifications would lead to the creation of an inclusive programme. The three intermediate outcomes are increased adherence to the yoga programme, less likelihood of adverse events and increased adherence among participants with varied capabilities, health conditions, impairments, and fitness levels. The final outcomes that the programme aims to achieve are increased adherence to strength and balance guidelines, and improved physical function and HRQoL outcomes.

Behaviour Change Techniques (BCTs) are the active ingredients in interventions that are thought to influence the causal processes that regulate behaviour (Michie et al., 2013). Michie et al. (2013) developed a taxonomy of 93 distinct BCTs clustered in 16 groups. Using this taxonomy to identify and categorise intervention components would aid in pinpointing the specific activity that would drive the change, and also enable replication and fidelity in implementation of the intervention. Based on this taxonomy, the appropriate BCTs have been selected for each intervention component to understand the underlying behaviour in the

translation of components to achieving the final outcomes. To get a deeper understanding of mechanisms, the barrier to physical activity and yoga practice that each intervention component addresses have also been identified. The mechanisms for each intervention component including BCTs, barriers to physical activity and yoga participation are presented in Table 33.

7.4.3 Assumptions

(i) Assumptions in Theory of change 1. It is assumed that the external agencies and individuals such as retirement homes, charities, and healthcare professionals will be cooperative and enthusiastic about promoting yoga. There are other barriers to physical activity such as cost that the programme has not considered, and it is assumed that the negative effects of unaddressed barriers will not undermine the operation of the programme.

(ii) Assumptions in Theory of change 2. The systematic review (Study 1) findings assert that yoga is effective in improving strength, balance and other physical function and HRQoL parameters. It is assumed that despite all the modifications suggested to make the programme appealing, appropriate and acceptable to older adults, the final yoga programme will remain effective in improving physical function and HRQoL outcomes. Another assumption is that identified factors associated with physical inactivity (aerobic PA) would also affect participation in strength and balance activities.

The programme does not assume that instructors would be aware of the appropriate posture modification, and recommends that training should be provided. However, it is assumed that posture modifications would reduce pain and injuries attributable to the yoga session. The final intervention was developed based on inputs from participants who are physically active, and belong to higher a socio-economic bracket. While the programme has been generalised for all older adults, inactive populations or those with severe impairments and health conditions, as well as those from deprived areas may have specific inputs that need to be incorporated.

7.4.4 Risks. While the programme has been developed to be appropriate for older adults in terms of reducing the potential for injuries and discomfort, the risk of adverse events still exists. There is a chance that participants will substitute other forms of PA with yoga, which could reduce adherence to the PA guidelines and lead to deterioration of health outcomes. Similarly, there is a risk that class-based or home-based yoga practice actually have the unintended consequence of increasing total sedentary time, as people may compensate and sit more if they feel they have done some activity.

Since it is difficult to clearly define progression in yoga, there is a risk that intermediate and advanced postures recommended by instructors may not really increase effort, and thus participants may not be gaining optimal health benefits.

Future testing and evaluation should consider risks and assumptions while assessing programme effectiveness.

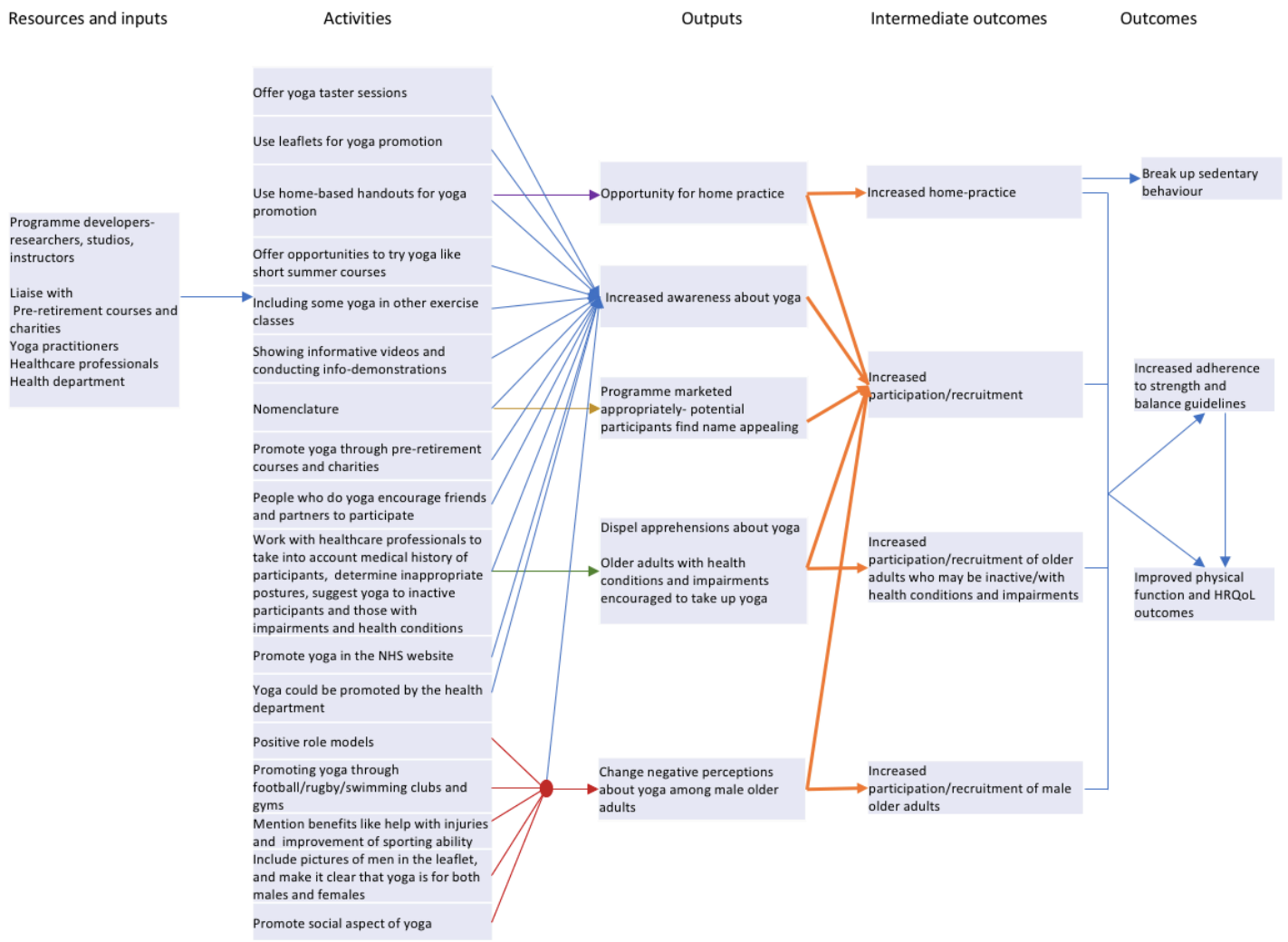


Figure 39. Logic model representation of Theory of change 1- recruitment to a yoga programme

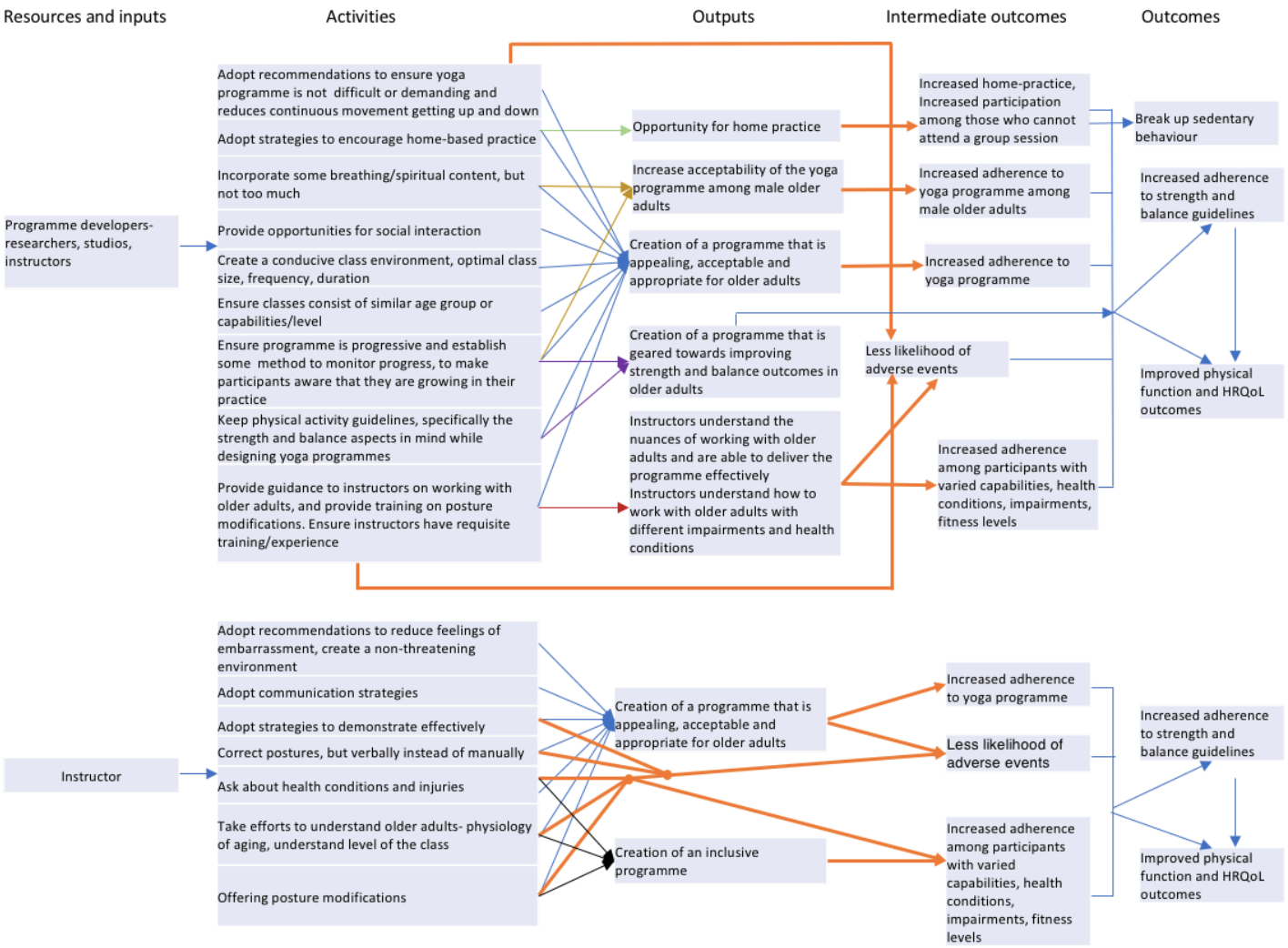


Figure 40. Logic model representation of Theory of change 2- adherence to a yoga programme

Table 33.

Mechanism of change- from activity to output

Activity	**Mechanism**			**Outcomes**
	Behavioural Change Technique aiming to increase participation or adherence among older adults	**Addressing barriers and motivators to PA participation**	**Addressing barriers and motivators and facilitators of yoga practice**	
Adopt recommendations to ensure yoga programme is not difficult or demanding	4.1 Instruction on how to perform a behaviour	1. Enjoyment/pleasure through PA (Mot) 2. Pain and discomfort during PA (Bar) 3. High intensity PA (Bar) 4. Increased self-efficacy/self-esteem/self-confidence (Mot) 5. Character of the programme-complexity and effort (Bar)	1. Would find yoga difficult and demanding	Increased adherence to yoga programme
Adopt recommendations to reduce continuous movement getting down and up from the floor	4.1 Instruction on how to perform a behaviour 6.1 Demonstration of the behaviour	1. Enjoyment/pleasure through PA (Mot) 2. Pain and discomfort during PA (Bar) 3. High intensity PA (Bar) 4. Character of the programme-complexity and effort (Bar)	1. Apprehensive about continuous movement getting down and up from the floor	Increased adherence to yoga programme
Ensure programme is progressive and establish some method to monitor progress, to make participants aware that they are growing in their practice	8.7 Graded tasks	1. A progressive programme is recommended for gaining additional benefits of exercise 2. Self-efficacy/self-esteem/self-confidence (Mot)	1. Participants need to feel they are progressing in their practice	Increased adherence to yoga programme

Strategies to encourage home-based practice and using home-based handouts	5.1 Information about health consequences 5.6 Information about emotional consequences 6.1 Demonstration of the behaviour 9.1 Credible source	1. Experiencing the health or physical functioning benefits of PA (Mot) 2. Experiencing the psychological health benefit of PA (Mot) 3. Lack of time (Bar) 4. Too high cost (Bar) – provides opportunity for home practice which is cheaper than attending classes 5. Competing commitments (Bar)	1. Older adults felt they may do shorter home practice session 2. Handouts are more widely acceptable and accessible than videos 3. Incorporating realistic pictures (older aged models and simple postures) would be more appealing to older adults	Increased home-practice Increased participation among those who cannot attend a group session
Incorporate some breathing/spiritual content, but not too much			1. Addresses apprehensions that breathing/spiritual content would be high 2. Older adults less likely to pursue yoga for spirituality/meditation 3. Less spiritual content suggested to encourage yoga participation among male older adults	Increased adherence to yoga programme
Providing opportunities for social interaction	12.2 Restructuring the social environment	1. Social interaction (Mot)/ no exercise companion (Bar)	1 Social interaction is an important element	Increased adherence to yoga programme
Conducive class environment	12.1 Restructuring the physical environment		1. Availability of props would help participants perform some postures 2. Participants do not like infringing on other's space	Increased adherence to yoga programme

Providing information on attire	4.1 Instruction on how to perform a behaviour		1. Lack of information on what to wear to a yoga class identified as a barrier	Increased adherence to yoga programme
Optimal class size			1. Preference for a smaller class	Increased adherence to yoga programme
Preferred duration and frequency:		1. Lack of time (Bar)	1. Preference for shorter classes among those new to yoga, and longer classes among regular yoga participants 2. Yoga classes too long identified as barrier 3. Preferred frequency of one or two classes per week	Increased adherence to yoga programme
Classes consisting of similar age group or capabilities/level		1. Self-conscious in a group of younger people or people at a more advanced level (Bar) 2. Lack of access to senior group activities (Bar)	1. Older adults expressed a preference to attend classes with people of the same age group/level 2. Teachers felt that not just age but capabilities should be taken into account	Increased adherence to yoga programme
Keep physical activity guidelines, specifically the strength and balance aspects in mind while designing yoga programmes	Ensuring that the programme is geared towards improving strength and balance outcomes in older adults			Programme improves strength and balance

Provide guidance to instructors on working with older adults, and provide training on posture modifications. Ensure instructors have requisite training/experience	4.1 Instruction on how to perform a behaviour 6.1 Demonstration of the behaviour 9.1 Credible source	1. Pain and discomfort during PA (Bar) 2. Increased pain (Bar) 3. Enjoyment/pleasure through PA (Mot) 4. Presence and quality of exercise instructor (Mot)	1. Training would help instructors to suggest appropriate modifications, variations, and incorporate postures to increase strength and balance 2. Quality of instructor found to be a barrier to yoga participation	Increased adherence to yoga programme Less likelihood of adverse events
Guidance for instructors:				
Adopt recommendations to reduce feelings of embarrassment, create a non-threatening environment	6.2 Social comparison 6.3 Information about other's approval	1. Self-efficacy/self-esteem/self-confidence (Mot) 2. Self conscious/embarrassed/intimidation/feel they can't keep up (Bar)	1. Fear of embarrassment 2. Non-competitive aspect of yoga and freedom to choose pace in a yoga class are motivators	Increased adherence to yoga programme
Adopt communication strategies			1. Good communication style, flow, audible, clear instructions, providing explanation appreciated by older adults	Increased adherence to yoga programme
Adopt strategies to demonstrate effectively	6.1 Demonstration of the behaviour	1. Presence and quality of exercise instructor (Mot)	1. Older adults stressed on the importance of demonstrating, and suggested strategies to demonstrate effectively	Increased adherence to yoga programme Less likelihood of adverse events
Correcting postures but verbally	4.1 Instruction on how to perform a behaviour		1. Moving around the class and correcting/adjusting postures was appreciated by older adults. However, manually correction could lead to injuries.	Increased adherence to yoga programme Less likelihood of adverse events

Asking about health conditions and injuries	3.1 Social support (advice, encouragement, counselling from staff)	1. Pain and discomfort during PA (Bar) 2. Programme tailored to participants capability (Mot) 3. Social interaction (Mot) 4. Social support (Mot)	1. Being informed about each individual, asking about health conditions and injuries and being caring appreciated by older adults	Increased adherence to yoga programme Less likelihood of adverse events Increased adherence among participants with varied capabilities, health conditions, impairments, fitness levels
Understanding older adults	3.1 Social support (advice, encouragement, counselling from staff)	1. Pain and discomfort during PA (Bar) 2. Programme tailored to participants capability (Mot) 3. Social interaction (Mot) 4. Social support (Mot)	1. Older adults felt that understanding ageing is an important quality in an instructor	Increased adherence to yoga programme Less likelihood of adverse events Increased adherence among participants with varied capabilities, health conditions, impairments, fitness levels

Offering posture modifications	4.1 Instruction on how to perform a behaviour 6.1 Demonstration of the behaviour	1. Pain and discomfort during PA (Bar) 2. Enjoyment/pleasure through PA (Mot) 3. Self-conscious/embarrassed/intimidation/feel they can't keep up (Bar) 4. Programme tailored to participants capability (Mot)	1. Offering alternative exercises, using props and providing easier options was suggested by older adults	Increased adherence to yoga programme Less likelihood of adverse events Increased adherence among participants with varied capabilities, health conditions, impairments, fitness levels
Yoga promotion strategies:				
Offer yoga taster sessions	6.1 Demonstration of the behaviour 4.1 Instruction on how to perform a behaviour	1. Experiencing the health or physical functioning benefits of PA (Mot) 2. Experiencing the psychological health benefit of PA (Mot) 3. Enjoyment/pleasure through PA (Mot) 4. No knowledge about exercise (Bar) 5. Irrelevance and inefficacy (Bar) 6. Too high cost (Bar)	1. Providing more information around yoga and publicising the benefits was a suggested strategy to promote yoga 2. Yoga taster were suggested to promote yoga 3. Experiencing benefits of yoga could address the barrier of lack of aerobic element 4. Those who have attended yoga sessions are more likely to participate in future	Increased participation and recruitment to a yoga programme

Leaflets	5.1 Information about health consequences 5.6 Information about emotional consequences 9.1 Credible source 11.2 Reduce negative emotions	1. No knowledge about exercise (Bar)/Knowing the benefits of PA (Mot) 2. Irrelevance and inefficacy (Bar) Providing information on: 3. Enjoyment/pleasure through PA (Mot) 4. Fear of injury or pain/ harm (Bar) 5. Fear of falls (Bar) 6. Less perceived stress through PA (Mot) 7. Independence/To maintain an active lifestyle (Mot) 8. Social interaction (Mot)/no exercise companion (Bar) 9. Too tired (Bar)	1 Providing more information around yoga and publicising the benefits was a suggested strategy to promote yoga, as people are more motivated to participate if they understood benefits. 2. Providing information on benefits could address barrier of no aerobic element 3. Barriers such as perceived lack of social interaction could be addressed by leaflets 4. Media cues such as posters are pathways to yoga 5. Incorporating realistic pictures (older aged models and simple postures) would be more appealing to older adults	Increased participation and recruitment to a yoga programme
Home-based handout as a promotion strategy	5.1 Information about health consequences 5.6 Information about emotional consequences 6.1 Demonstration of the behaviour	1. No knowledge about exercise 2. Experiencing the health or physical functioning benefits of PA (Mot) 3. Experiencing the psychological health benefit of PA (Mot)	1. Incorporating realistic pictures (older aged models and simple postures) would be more appealing to older adults	Increased participation and recruitment to a yoga programme Increased home-practice

Offer opportunities to try yoga like short summer courses	4.1 Instruction on how to perform a behaviour 5.1 Information about health consequences 5.6 Information about emotional consequences 6.1 Demonstration of the behaviour	1. Experiencing the health or physical functioning benefits of PA (Mot) 2. Experiencing the psychological health benefit of PA (Mot) 3. Enjoyment/pleasure through PA (Mot) 4. No knowledge about exercise (Bar) 5. Irrelevance and inefficacy (Bar) 6. Too high cost (Bar)	1. Short summer courses suggested as a strategy to promote yoga	Increased participation and recruitment to a yoga programme
Including some yoga in other exercise classes	4.1 Instruction on how to perform a behaviour 6.1 Demonstration of the behaviour	1. Experiencing the health or physical functioning benefits of PA (Mot) 2. Experiencing the psychological health benefit of PA (Mot) 3. Enjoyment/pleasure through PA (Mot) 4. No knowledge about exercise (Bar) 5. Irrelevance and inefficacy (Bar)	1. Including some yoga in other exercise classes suggested as a strategy to promote yoga	Increased participation and recruitment to a yoga programme
Showing informative videos and conducting info-demonstrations	6.1 Demonstration of the behaviour 5.1 Information about health consequences 5.6 Information about emotional consequences	1. No knowledge about exercise (Bar)/Knowing the benefits of PA (Mot) 2. Irrelevance and inefficacy (Bar) 3. Enjoyment/pleasure through PA (Mot) 4. Experiencing the health or physical functioning benefits of PA (Mot) 5. Experiencing the psychological health benefit of PA (Mot) Providing information on: 6. Fear of injury or pain/ harm (Bar)	1. Showing informative videos and conducting info-demonstrations suggested as a strategy to promote yoga	Increased participation and recruitment to a yoga programme

		7. Fear of falls (Bar) 8. Less perceived stress through PA (Mot) 9. Independence/To maintain an active lifestyle (Mot) 10. Too tired (Bar)		
Nomenclature			1. Adding a tag line to “yoga” that would elaborate on who it's for, what it is, and the benefits was suggested	Increased participation and recruitment to a yoga programme
Positive role models	6.1 Demonstration of the behaviour 6.3 Information about others approval 9.1 Credible source	1. Dislike/disinterest PA 2. Irrelevance and inefficacy 3. Lack of motivation (Bar)	1.Positive role models suggested as a strategy to promote yoga, especially among male older adults	Increased participation and recruitment to a yoga programme

Promote yoga through football/rugby/swimming clubs and gyms	5.1 Information about health consequences 5.6 Information about emotional consequences 9.1 Credible source		1. Promoting yoga through football/rugby/swimming clubs and gyms would encourage male older adults to participate	Increased participation and recruitment to a yoga programme
Promote through pre-retirement courses and charities	5.1 Information about health consequences 5.6 Information about emotional consequences 9.1 Credible source	1. No knowledge about exercise (Bar)/Knowing the benefits of PA (Mot) 2. Irrelevance and inefficacy (Bar) 3. Enjoyment/pleasure through PA (Mot) 4. Experiencing the health or physical functioning benefits of PA (Mot) 5. Experiencing the psychological health benefit of PA (Mot) Providing information on: 6. Fear of injury or pain/ harm (Bar) 7. Fear of falls (Bar) 8. Less perceived stress through PA (Mot) 9. Independence/To maintain an active lifestyle (Mot) 10. Too tired (Bar)	1. Promoting yoga through pre-retirement courses and charities suggested as a strategy to promote yoga	Increased participation and recruitment to a yoga programme
People who do yoga encourage friends and partners to participate	3.1 Social support (unspecified)	1. Social support (Mot)/ no exercise companion (Bar)	1. It was suggested that people who do yoga could encourage friends and partners to participate	Increased participation and recruitment to a yoga programme

Healthcare professionals could promote/recommend yoga	9.1 Credible source	Healthcare professionals could address: 1. Health conditions/illness (Bar) 2. To control chronic conditions (Mot) 3. Helps reduce/cope with or relieve pain (Mot) 4. Increased pain (Bar) 5. No knowledge about exercise (Bar)/ Knowing the benefits of PA (Mot) 6. Irrelevance and inefficacy (Bar) 7. General physical function 8. Fear of injury or pain/ harm 9. Fear of falls (Bar) 10. Too tired	1. Promotion of yoga by healthcare professionals was a suggested strategy 2. Instructors working with healthcare professionals to understand medical issues and contraindications of patients 3. Barriers such as will hurt, will worsen health problems could be addressed by healthcare professionals 4. Health-related events, such as a medical diagnosis could be a trigger to join yoga among older participants, and healthcare professionals could act as a catalyst	Increased participation and recruitment to a yoga programme Increased participation/recruitment of older adults who may be inactive/with health conditions and impairments
Yoga could be promoted by a government health department	5.1 Information about health consequences 5.6 Information about emotional consequences 9.1 Credible source	1. No knowledge about exercise 2. Knowing the benefits of PA 3. Irrelevance and inefficacy		Increased participation and recruitment to a yoga programme
Promoting yoga via relevant website e.g. NHS website	5.1 Information about health consequences 5.6 Information about emotional consequences 9.1 Credible source	1. No knowledge about exercise 2. Knowing the benefits of PA 3. Irrelevance and inefficacy		Increased participation and recruitment to a yoga programme

7.5 Comparison of Final Theory of Change Models and the Initial Model

One notable difference was that in the final version, the model was split into two. The initial theory of change model had elements of recruitment and adherence within the same model, but two separate models were created to address these two elements during the development process so that the mechanisms for these goals can be examined rigorously. Two main resources/inputs were identified in the initial model including programme developers like yoga teachers, researchers and studio owners, and the health department. Theory of change 1 (participation/recruitment) added to this list. Healthcare professionals, other yoga practitioners, pre-retirement courses and charities were seen as important groups that could influence yoga participation among older adults. In Theory of change 2 (adherence), instructors were recognised as very important and the guidance for instructors developed as a part of this project plays a vital part in making the yoga programme appealing, acceptable and appropriate.

The activities section of the models was fleshed out based on the final yoga programme components, and lead to several additional hypothesised outcomes as compared to the initial model. For example, in Theory of change 1, healthcare professionals promoting yoga would help dispel apprehensions about yoga and encourage older adults with health conditions and impairments encouraged to take it up. In Theory of change 2, providing guidance and training for instructors on working with older adults would help instructors work effectively with those who have impairments or health conditions. Several activities also lead to the creation of an inclusive programme. Reduced likelihood of adverse events is another outcome identified in Theory of change 2, which was not a part of the initial model. Increased participation and adherence among inactive older adults and those with varied capabilities and health conditions were hence identified as intermediate outcomes in Theory of change 1 and 2. This aspect was not recognised in the initial model. The final theory of change models were also complemented with a table (Table 28) that describes the mechanisms by which these changes would be brought about. The final models benefited from a rigorous development process, and helped capture new elements, and nuances an explored the mechanisms of change in detail.

7.6 Reflection on the Place of Theory of Change Models within Intervention Development

The theory of change models provided a deep understanding of how programme would operate. The models helped identify crucial stakeholders such as programme developers, the health department, healthcare professionals, and link them with the programme components and anticipated short and long term outcomes, to reveal complexities and interconnections. Importantly, the process of developing the models established the link between the programme components and the causes of inactivity. This ensured that the developed yoga programme is tied to the abundant literature elucidating the source of the problem.

In this PhD, the initial model presented was refined based on inputs from the target population and other stakeholders, and from previous literature. This sequence could be improved in future intervention development studies by developing the initial model based on previous literature and then revising the model based on empirical data procured. This would highlight the differences in the proposed mechanisms between the models, and challenge or support earlier hypothesis. This process of understanding differences between the models would provide a deeper understanding of how the programme would operate.

Chapter 8. Discussion and Next Steps

8.1 Summary

For studies 1 to 4, the findings, strengths and limitations have been discussed within each respective chapter. In this final chapter, an overall summary is presented, followed by a discussion on strengths and limitations, recommendations for future research and applications of findings. The process of developing a yoga intervention for older adults in Scotland commenced with establishing the evidence base (Study 1), followed by consultations with stakeholders (Study 2, KE event and Study 3). Based on the findings from these steps, the final intervention components were collated, and theory of change models were developed to understand how the intervention would work in the short-term and ultimately improve physical function and HRQoL in older adults in the longer-term (Study 4).

In Chapter 2, four main outputs from this PhD were identified using a logic model (Figure 6). These included: (i) Systematic review assessing the effectiveness of yoga in improving physical function and HRQoL (ii) Development of an appealing, appropriate and acceptable yoga programme for older adults (iii) Compilation of strategies to encourage yoga participation in an older adult population and (iv) Include intervention components that improve adherence to home-based exercises. A summary of the four outputs is presented below.

8.1.1 Systematic review. An important step in intervention development is identifying the evidence base (Craig et al., 2013). Since no updated systematic review examined the effects of yoga in an older adult population not characterised by any specific clinical condition, this was undertaken as a part of this PhD. The search was conducted in September 2017. Findings of the systematic review showed that yoga improves balance, lower body flexibility, lower limb strength, depression, perceived mental health, perceived physical health, sleep quality and vitality compared with inactive controls; and lower limb strength, lower body flexibility and depression compared with active controls in a general older population.

8.1.2. Development of an appealing, appropriate and acceptable yoga programme for older adults. The development of the yoga programme was based on findings from Study 2, the KE event and Study 3. Study 2 explored perceptions of yoga among older adults with yoga experience, as well as those those who had never participated in yoga. Overall, yoga was perceived as slow and not strenuous by all participants. A key finding was that older adults participating in yoga both enjoyed and held a positive view of this activity. These findings strengthen the potential of yoga as an appealing and acceptable activity. Apprehensions with yoga cited by older adults with no yoga experience included feeling that it will be difficult and demanding, anxiety about continuous movement between getting down and up from the floor, fear of embarrassment, lack of information around yoga and, concerns about meditative and spiritual aspects. Results from Study 2 also included guidance for instructors while working with an older adult population. These consisted of communication strategies (audibility, clear instructions and demonstration), creation of a non-threatening and comfortable environment, understanding ageing and individual participants (health status, injuries) with an empathic approach, being aware of class and level, and offering alternative postures and using props as required. Training and experience of instructors was very important to older adults who felt that instructors should be inspiring and appropriately qualified. Reasons for the gender bias and methods to address this were also suggested (see section 8.2 for further details).

Further consultations with the target population were carried out in a feasibility study (Study 3) where intervention components aiming to address themes and barriers from Study 2 were evaluated. Three intervention delivery modes were investigated in Study 3 – a leaflet for promoting yoga in an older adult population, yoga taster sessions, and home-based sessions supported by a handout. The appeal, appropriateness and acceptability of the intervention components were assessed and further inputs to refine the yoga programme were collated. Data were also collected from stakeholders such as yoga instructors, studio owners and researchers through a) a KE event conducted with this group and b) an in-depth interview with the instructor who conducted the taster sessions in Study 3.

In Study 4, the yoga programme intervention components were compiled by assimilating data from the consultations with the target population, yoga instructors, studio owners and researchers. The programme developed is appealing, appropriate and acceptable as components addressed the identified apprehensions. Components on class content (class structure, poses to include and avoid), guidance for instructors, including social interaction and class details (class environment, class size, duration and frequency, name, age-group) also aimed to make the programme appealing, appropriate and acceptable for older adults.

8.1.3 Strategies to encourage yoga participation among older adults. Based on Study 1, 2, 3 and the KE event, strategies to promote yoga in an older adult population were compiled. Lack of information on yoga was identified as a barrier to participation. Study 3 results showed that the leaflets, taster sessions and home-based handouts were effective in addressing this barrier. Other suggested strategies to address this barrier were promoting and incorporating some yoga in other exercise classes, informative videos and info-demonstrations, promoting yoga through pre-retirement courses and charities, and in the NHS website. Encouraging those who do yoga to motivate friends and family to try it (snowballing), and offering yoga summer courses were also suggested. It was felt that adding a tag line to the name "yoga" that would elaborate on who the programme was for and its benefits would help attract older adults. Healthcare professionals are in a position to address many of the barriers to yoga and enlisting their support in promoting yoga was considered significant. Promoting yoga through football/rugby/swimming clubs and gyms and having positive role models were suggestions to encourage yoga participation among male older adults.

8.1.4 Intervention components to increase adherence to home-based participation. Although participants in Study 2 and 3 expressed a preference for a class-based session, they felt that home-based sessions could help with regularity if participants couldn't attend a class, or if classes were suspended. Handouts were found to be more acceptable and accessible than videos to this population as a method of supporting home practice. Several suggestions to improve adherence to a home-based session were made such as including exercises that participants have

done before under the supervision of a teacher, using a chair, and providing a simple handout with clear instructions.

The PhD project achieved its principle objective of developing a yoga programme that is appealing, acceptable and appropriate to older adults in Scotland. The secondary aim of identifying strategies to promote yoga in this population was also achieved. The main aspects of the programme are represented in Figure 41. Two theory of change models were developed to examine how the programme components would (i) increase recruitment to and participation in a yoga programme (Theory of change 1) and (ii) achieve adherence to a yoga programme (Theory of change 2).

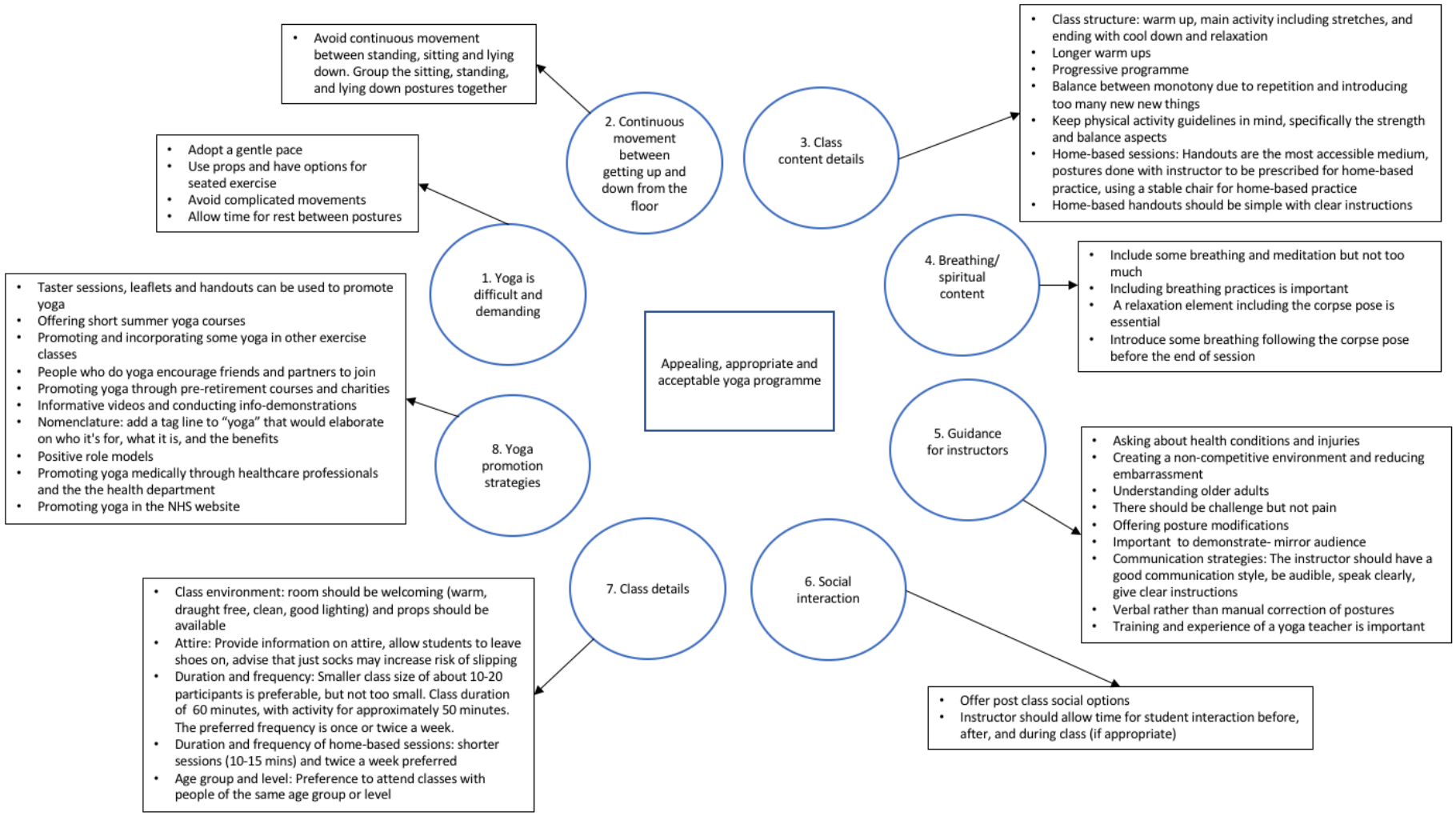


Figure 41. Main intervention components from the final yoga programme

8.2 Exploring the Gendered Nature of Yoga Participation

A gender bias has been observed with respect to yoga participation, and women are more likely to participate in yoga than men (Ding & Stamatakis, 2014). In Scotland, the percentage of older men participating in yoga/pilates was very low at 1% (65-74 years) and 0% (75+ years) (Currie, 2017). Exploring the gendered nature of yoga participation was hence undertaken as a part of this PhD. This endeavour was met with some obstacles. Recruiting male participants for a focus group in Study 2 was difficult, and interviews had to be conducted with five male participants who formed only 26% of the total sample. Six of the 17 participants (35%) in Study 3 were male. Despite recruitment difficulties, reasons for the observed gender bias in yoga and strategies to overcome male-specific barriers were identified in Study 2. Reasons for lower yoga participation rates among older males included (i) perceiving yoga as a feminine activity, (ii) aversion to being viewed as not competent (iii) engaging in other exercises (iv) gender bias was not unique to yoga as older males preferred not to join group activity classes (v) older males may not pay attention to long-term health issues. Intervention components to increase yoga participation among male older adults include (i) having positive role models, (ii) promoting yoga through football/rugby/swimming clubs and gyms, (iii) promoting the social aspect of yoga (iv) publicising benefits like help with injuries and improvement of sporting ability through a leaflet and (v) including pictures of men in the leaflet, and making it clear that yoga is for both males and females. Intervention components to increase adherence of male older adults to yoga programmes include (i) incorporating some breathing/spiritual content but not making the session too contemplative and (ii) ensuring that the programme is progressive, establishing some method to monitor progress.

It should be noted that results from Study 2 indicated that persuading older males to participate in yoga may prove ineffective as it may be difficult to change rigid perceptions of yoga as a feminine activity, and their reluctance to join activity classes. It was also suggested that efforts to encourage yoga participation should be directed towards younger men, as older men are now too set in their ways. In Study 3, although framework analysis to systematically study differences in perceptions of

men and women was not conducted, no bias in responses was detected and male participants found the session as appealing as females. However, since the men were recruited from activity centres, the sample may be biased in that male participants recruited were not averse to activity classes as suggested in Study 2. Hence, the effectiveness of the final intervention components, specially the promotion strategies in attracting older men is uncertain and need to be evaluated. Given these findings targeting the female older adult population may be more pertinent. Female older adults are an especially vulnerable population, and it is argued in the paragraph below that yoga's value may lie in providing opportunities for older women to increase PA levels and improve health outcomes.

Female older adults are likely to have lower relative muscle strength (load/fat free mass) than men (Monteiro et al., 2016), and females also have lower absolute strength compared to males (Frontera, Hughes, Lutz, & Evans, 1991). Female older adults have lower MVPA levels compared to males (Currie, 2017). Men are more likely to meet MS guidelines across all age groups in Scotland, with 91% of women (compared to 84% of men) aged 75+ years engaging in no MS sessions per week (Strain, Fitzsimons, Foster, et al., 2016). Only 12 % of women aged 65 years and over in Scotland met the BC guidelines compared to 19% of men (Strain, Fitzsimons, Foster, et al., 2016). Global life expectancy in 2016 was 74.2 years for females and 69.8 years for males (World Health Organization, n.d.). Following a similar trend, life expectancy in the UK (2015-2017) is higher for women (82.9 years) than men (79.2 years) (Office for National Statistics, 2018b). Moreover, in OECD (Organisation for Economic Co-operation and Development) countries, on an average, men left the labour force before age 64 and could expect 18 years of retirement in 2007, whereas women stopped working at age 63 resulting in more than 22 years of retirement (World Health Organization, National Institute on Aging, & National Institutes of Health, 2011). Though women live longer than men, they have poorer health status (World Health Organization et al., 2011), and medical spending in women is higher than in men (De Nardi, French, Jones, & McCauley, 2016). Women are more likely than men to have a common mental health problem in England (McManus, Bebbington, Jenkins, & Brugha, 2016), and 28% of older

women were estimated to be affected by depression, compared to 22% of men in 2005 (Craig & Mindell, 2007).

The increase in the percentage of Scottish adults aged 65 and over participating in yoga can be attributed to the increase in female participation from three percent in 2014 to six percent in 2016 (Currie, 2017; Gill, 2015). It appears that females have more of an affinity for yoga than males. Hence, it can be viewed positively that yoga is a PA programme that is attractive to older women, and could encourage this vulnerable group to increase strength and balance activities.

8.3 Comparison with Other Yoga Interventions Developed for Older Adults

Four other studies addressed yoga intervention development for older adults (section 2.1.1.1.1, Table 5). Similarities between the programme developed by Barrows and Fleury (2017) and the current study included intervention components relating to using props and providing posture modifications. Both programmes are progressive in nature (advancing in difficulty over time), and stress on non-violence, where participants adopted their own pace, resting when appropriate. In the current study, participants were encouraged to reflect on their bodies and ageing during yoga practice. Barrows and Fleury (2017) had a similar component, but reflection on participants' goals, values, strengths and patterns of behaviour was also encouraged. In both programmes, emphasis was placed on the instructor's attributes such as communication style, rapport with participants, and training, experience and competence. Similar instructor qualities were desirable in both programmes (warm, friendly and non-judgemental (Barrows & Fleury, 2017); sympathetic, approachable, patient, encouraging, and being sensitive to the needs of older adult participants in the current programme). Communicating information clearly was mentioned in both programmes.

The programme by Smith et al. (2017) and the current programme had some common intervention components such as providing modifications, creating a non-competitive environment where participants don't feel pressured to push themselves beyond their capacity. Participants were not transferred to the floor in the study by

Smith et al. (2017) due to concerns about mobility and safety of participants, and a parallel component to avoid continuous movement between standing and getting down on the floor was included in the current programme. Breathing was included in both programmes. Smith et al. (2017) stressed on breath awareness during poses, with an emphasis on when to inhale and exhale. The current study identified that breathing during postures was confusing for older adults and advised that a detailed explanation should be provided by instructors.

Home-based components in the Smith et al. (2017) programme included performing three poses at home in approximately 10 minutes on three days guided by a booklet. In the current programme, based on consultations with older adults, home-based practice was recommended on two days for 10-15 minutes using a home-based handout. While the home-based handout had three postures and a breathing exercise, producing a series of handouts has been recommended. The postures in the booklet for home practice (Smith et al., 2017) were chosen to target fall risk, whereas in the current programme they were chosen to enhance strength, balance and flexibility. In both programmes, the home-based postures were also conducted in class.

The focus of the development process in the study by Hariprasad, Varambally, et al. (2013) was on postures. Apart from the postures used, and the frequency and duration of sessions, no other intervention components were provided. Chen et al. (2007) also focused on postures with two additional intervention components. Ensuring that postures were carried out gently was a component that was also captured in the current programme. Another component in the programme by Chen et al. (2007) was that one instructor demonstrated the yoga postures while following a pre-recorded tape of the programme, and another instructor adjusted participants' postures to reduce injuries. While the current programme does not use a pre-recorded tape, having more than one instructor for a larger class was recommended. Using verbal instead of physical adjustment of postures was endorsed in the current programme, but the type of adjustment was not specified by Chen et al. (2007).

Yoga philosophy emphasises being non-judgemental and non-competitive. Hence, it is not surprising that these aspects appear in other interventions as well. However, several class content details like balance between monotony from repeating postures and introducing too many postures, not including very high spiritual content, and providing avenues for older adults to share information on health issues with instructors are unique to the current programme. Offering opportunities for social interaction after the session is an important intervention aspect which is only included in the current programme. The current programme has several unique components as it addresses barriers expressed by older adults identified through consultations with the target population. Moreover, consideration of strength and balance guidelines was not mentioned in the other programmes. Some minor additional components in the yoga programmes by Barrows and Fleury (2017) and Smith et al. (2017) are not included in the current programme:

(i) The final 10 minutes of every session was allocated to conducting a group discussion to stimulate interaction between participants (Barrows & Fleury, 2017). This was also used to deliver educational components such as motivational strategies (goal setting, self-monitoring, social support), and problem solving. This component was based on the wellness motivation theory used in programme development and authors postulated that this would help anticipate and overcome obstacles to health behaviour change.

(ii) Yoga principles of physical alignment were taught and repetitively reviewed during each class (Smith et al., 2017). Participants were taught to monitor their breath as a method to gauge safety. Shallow breathing was an indicator that attention should be paid to alignment. Physical alignment cues included “the 4 corners of the foot, range of motion of the joints (unsafe rotation or misalignment of the knees, hips, shoulders and neck), hyper or hypo mobility issues and end-range over-stretching” (Smith et al., 2017, p. 121). No references were found for these recommendations in the published study. These recommendations could be explored in greater detail and included in the next iteration of the current programme if they are evidence based.

8.4 Strengths of the Thesis and Contribution to the Field

8.4.1 Strengths of the thesis. The three main limitations in previous studies that developed yoga interventions for older adults (Barrows & Fleury, 2017; Chen et al., 2007; Hariprasad, Varambally, et al., 2013; Smith et al., 2017) were the limited use of intervention development frameworks, limited consultations with the target population and limited use of theory. These limitations have been addressed in this PhD thesis. A strength of this thesis is the use of intervention development frameworks to aid intervention design. This allowed intervention development to be carried out according to best practices in a systematic and transparent way. The use of a framework increases the likelihood of success of the intervention (Wight et al., 2016). Previous studies that had not utilised these frameworks often move ahead to pilot and feasibility testing with minimal consultations with the target group (Hariprasad, Varambally, et al., 2013; Smith et al., 2017). Understanding the underlying mechanisms though which the intervention would achieve the desired outcomes has been recommended by development frameworks, and this has not been explored by many yoga programmes (Chen et al., 2007; Hariprasad, Varambally, et al., 2013).

This is one of the first studies in the UK to use consultations with the target population to develop a yoga intervention for older adults. While other studies (Tew et al., 2017) have conducted pilot studies and obtained qualitative information from participants post-intervention to assess enjoyment and acceptability, stakeholders have been involved in the initial stages of development in the current project. Moreover, the barriers to participation among older adults who had never experienced yoga using qualitative methods had never been studied. The choice of focus group discussions and interviews for data collection in Study 2 and Study 3 lead to the collection of rich data on perceptions of yoga, as well as apprehensions and motivators relating to yoga practice. Consultations with older adults with and without yoga experience helped identify components that would improve appeal, appropriateness and acceptability.

The thesis also commented on fidelity by procuring data on the instructor's experience of delivering the intervention. This was important to ascertain whether the intervention components could be translated to practice and delivered seamlessly.

Only one other yoga study has proposed a model to understand the mechanism of change that would lead to achieving cardiovascular health outcomes in older adults (Barrows & Fleury, 2017). Developing theory of change models for the current project helped the deconstruction of behaviour and understanding motivations. Another strength is that the study analysed how the developed intervention would overcome barriers to PA participation, and barriers to yoga participation, and, identified the behaviour change techniques that would ultimately lead to increased adherence to MS and BC guidelines.

In summary, the strengths of the thesis lie in the use of intervention development frameworks, consultations with the target population using appropriate data collection methods, assessing fidelity of delivering the programme, and understanding the theory of change.

8.4.2 Contribution to literature. Establishing the evidence base was the first intervention development step recommended by the MRC framework for the development of complex interventions (Craig et al., 2013). In line with this recommendation, a systematic review and meta-analysis was conducted (Study 1) which provided valuable data establishing that yoga can be promoted as an intervention to improve physical function and HRQoL in older adults. This is the most up to date review in the field offering a synthesis of a comprehensive list of physical function and HRQoL measures. The review was also novel in that it compared yoga with active and inactive controls, and provided evidence of the effectiveness of yoga in an older adult population not recruited on the basis of a health condition.

At a broad level, the thesis aimed to answer the question; if yoga is effective in improving numerous health outcomes, then why do so few older adults participate?

The consultations with the target population and stakeholders like instructors, researchers and studio owners helped identify intervention components that make yoga less demanding for older adults, that address apprehension relating to breathing and spiritual content, and provide guidance for instructors.

A unique contribution to the field from this PhD was the development of strategies to promote yoga among older adults. Two strategies to encourage yoga participation were evaluated through qualitative methods. Results revealed that taster sessions and leaflets were effective in increasing awareness and promoting yoga among older adults. Moreover, participants felt that the home-based handout could also be used to provide information about yoga. Several other avenues to increase participation in yoga have been recommended.

This PhD explored the concepts of appealing, appropriate and acceptable. It makes intuitive sense that these concepts are important while developing an intervention, and, interventions that are not appealing, appropriate and acceptable are unlikely to successful. Moreover, these terms are used in several yoga studies (Chen et al., 2007; Cheung et al., 2014; Smith et al., 2017) and broader PA studies (Blamey et al., 2013). However, there are no standardised definitions for these terms. This study has proposed working definitions that could be used while establishing if interventions are appealing, appropriate and acceptable to the target population. However, future research studies could use methods such as Delphi surveys to develop standardised definitions.

Many yoga programmes include home-based sessions as a part of the intervention (Oken et al., 2006; Tew et al., 2017; Tiedemann et al., 2013). To my knowledge, this is the first study to understand perceptions around home-based yoga practice in older adults and propose intervention components that would encourage adherence to a home-based session, including the design of a home-based handout.

Intervention components such as creating a non-competitive environment, and ensuring that participants don't feel forced to perform postures appear in other yoga

programmes since these echo the non-violent and non-judgmental ethos of yoga. In this thesis, these components were arrived at through consultations with older adults and hence the developed programme is a congregation of yoga philosophy and needs of older adults. Yoga already encompasses these elements, but the thesis helped highlight them as important mechanisms to address barriers to yoga and physical activity participation. For example, the recommendations to reduce feelings of embarrassment, and create a non-threatening environment addresses barriers to yoga participation such as fear of embarrassment as well as barriers to PA participation such as feeling self-conscious or intimidated (Table 28).

8.5 Limitations

8.5.1 Saturation and sample size. Sample size in qualitative research is not determined by power calculations since the objective is to explore and examine diverse opinions of participants rather than the frequency of opinions (O'Reilly & Parker, 2013). The criterion of saturation usually determines sample size, and data collection is often discontinued when saturation is achieved (Saunders et al., 2018). Saturation originated from grounded theory, and is defined as the point during coding where no new codes occur or where there are no new emergent themes (Saunders et al., 2018). Some limitations have been levelled against the concept of saturation. Saturation can be viewed as a "statement about the unobserved based on the observed" (Saunders et al., 2018, p. 1904). Characterising saturation as a point that can be determined by the researcher has been criticised, as there is no certainty that new themes won't emerge (Saunders et al., 2018). In research studies, there is ambiguity about when saturation is reached, and studies have continued sampling even after saturation in order to obtain objective evidence of achieving saturation (Saunders et al., 2018). Hence due to its conceptualisation, there are inconsistencies in the way saturation has been used in qualitative studies (Saunders et al., 2018). There are also issues around the practicality of saturation, as the inability to pre-determine sample size makes it difficult for researchers to estimate time and cost (Boddy, 2016). Saturation is not always the best way to judge the quality of research, and not achieving saturation does not invalidate findings (O'Reilly & Parker, 2013). However, it is advised that qualitative studies should justify the data collection methods used, highlight strategies to ensure rigor in data collection and analysis (O'Reilly & Parker, 2013), and report limitations.

In this thesis, the sample size was 19 participants in Study 2 and 17 participants in Study 3. Saturation was not explored due to time and resource constraints. However, efforts were taken to report data collection methods as well as issues with recruitment such as difficulty in recruiting men and non-yoga participants. Focus groups were chosen as the main method for data collection as the aim was to get a group perspective, and not deep individual histories and views (Barbour, 2007). It was anticipated that interaction among the group members would provide richer information (Barbour, 2007). Individual interviews were only conducted in cases where it was difficult to recruit participants. Another method to enhance rigour in data collection and analysis was the use of triangulation in Study 3, through which findings were confirmed and a comprehensive evaluation of intervention components were obtained. Some studies have estimated that for thematic analysis, 12 participants may yield sufficient data in a relatively homogenous group (Ando, Cousins, & Young, 2014). It can be concluded that while the sample size in the current study was small, adopting appropriate data collection and analysis methods, as well meticulous reporting enhanced the rigor and quality of the study.

8.5.2 Sample demographics. For Studies 2 and 3, participants were recruited mainly from fitness centres. Due to the venues where recruitment took place, both the samples consisted predominantly of active older adults. We can also infer that the samples belonged to a higher socio-economic stratum, as they could afford to attend activity classes in the central areas of Edinburgh. Although some participants in Study 2 were recruited from non-activity programmes at a local leisure centre such as singing classes, the thesis did not adequately capture the views of inactive older adults from suburban and rural areas, and those belonging to lower socio-economic brackets. This may affect the generalisability of the findings.

A qualitative study examined the barriers and facilitators to yoga practice among ethnic minority and low-income adults in the US (Spadola et al., 2017). Barriers included (i) the perceptions that yoga is not physical in nature (ii) a focus on stretching (iii) it would not yield weight loss benefits (iv) a fear of injury (v) perceived lack of ability to perform the practices (vi) preference for other physical activities, and (vii) scheduling difficulties. Facilitators of yoga engagement included instructor characteristics like effective communication, down-to-earth and

knowledgeable, preference for easy or beginner level classes, and promotional messaging that highlight the potential benefits of yoga, such as stress reduction. Although the average age of participants was 47.9 (SD = 15.7) years, the barriers and facilitators cited are similar to those identified in this thesis, and have been addressed in the final intervention. We could postulate that despite this demographic of the older adult population not being represented in this thesis, the additional data is not likely to be vastly different from current findings.

The final yoga programme does not address cost and environmental factors. While cost was identified as a barrier to yoga participation among older adults in another qualitative study (Wertman et al., 2016), it was not mentioned by participants in Study 2 or 3. Environmental factors such as access to recreational facilities or exercise programmes and access to transport facilities have been mentioned as barriers to physical activity participation (Barnett et al., 2017), but were not brought up during consultations with target populations in this thesis. This could be attributed to sampling, as the sample mainly consisted of older adults who are already a part of fitness or leisure centres, and did not perceive cost or lack of access as issues. Although cost was not explicitly addressed in the final intervention, creating an appealing home-based programme would address this barrier.

8.5.3 Methodology. In Study 4, evidence from Studies 1-3 of the PhD and other research studies were consolidated to develop the final intervention. Broad themes had started to emerge in Study 2 (Figures 20 - 24), and were developed and refined based on data from Study 3. The structure of the final intervention took the shape of eight broad themes under which intervention components were categorised (Figure 41). However, a rigorous methodology could have been adopted for this process. For example, Farmer, Robinson, Elliott, and Eyles (2006) developed a triangulation protocol to integrate multiple data sets such as interviews and reports. They identified themes from each data source and compared findings to determine if there is convergence with respect to the essence of meaning and prominence of themes. They also compared assessments of convergence among multiple researchers to clarify interpretations of findings. In this PhD, though the final intervention was

compiled by the lead instructor, components and their interpretation were discussed and refined along with the supervisory team. Dissonance in the results were handled by discussing conflicts within the final programme (section 6.9). Although an established method was not adopted while compiling the final intervention, transparency and meticulous reporting have helped develop a comprehensive final intervention that captured the essence of the data from all sources.

8.6 Revisiting Objectivity and Trustworthiness

The steps were taken to ensure objectivity and a high level of data trustworthiness were outlined in the methodology section. During the PhD process, other strategies to maintain objectivity were introduced. This section reflects on these measures and provides a summary.

8.6.1 Meticulous reporting. Detailed reporting of procedures, methods and results for all studies reduced bias and enhanced trustworthiness of the data. The systematic review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Moher et al., 2009), and the protocol was registered in advance on PROSPERO. The COREQ check list (Tong et al., 2007) was adhered to while reporting on the qualitative studies. Reporting of participant quotations to illustrate themes was suggested in the COREQ checklist and this aided unbiased reporting. These measures helped maintain objectivity and improved quality of the studies.

8.6.2 Objectivity and trustworthiness in qualitative studies.

(i) Co-moderator. Enlisting the help of a co-moderator was suggested by (Barbour, 2007). The recommended responsibilities of co-moderator include ensuring that the main topics are coved during the focus groups by asking supplementary questions, and participating in a debrief with the moderator immediately after the sessions (Pickering & Watts, 2003). For this PhD project, a co-moderator was present during the focus groups in Study 2. As suggested, their contributions included asking supplementary questions during the session. In addition, a discussion between moderators ensued immediately after the session, so that the insights of the co-moderator were captured.

(ii) Varied data collection methods. As mentioned earlier, incorporating multiple data collection methods provides more insightful data and a better understanding of the phenomenon being explored (Bekhet & Zauszniewski, 2012). In the current PhD project, the use of different data collection techniques in both qualitative studies and more so in Study 3 provided participants with an array of options to share their views. The use of focus groups, questionnaire and interviews helped capture group interactions, and also provided anonymity to share private opinions. This aided interpretation and acquiring a deeper understanding of participants views, thus enhancing trustworthiness of data.

(iii) Critical friends. A paper discussing methods to indicate rigour in qualitative research, presented a critique of the concepts of member checking, and inter-rater reliability (Smith & McGannon, 2017). It is not possible to know if the participants actually faithfully engaged in member checking, and may skim over findings, or they may try to appease the investigator by agreeing. Time would have elapsed between initial data collection and member checking, during the course of which perceptions could have changed. Hence the effectiveness of member checking in judging accuracy has been questioned. Inter-rater reliability is also subject to criticisms. The knowledge and experience of coders and organisational power hierarchies render it an inappropriate method to judge reliability. Although multiple coding of entire datasets has been discouraged due to time and cost factors, it has been suggested that of multiple coding of some sections such as emergent coding frameworks may be appropriate (Barbour, 2001). In Study 2 an initial transcript was coded by three researchers, and two researchers coded a transcript in Study 3. Smith and McGannon (2017) advocate the concept of critical friends as a means of achieving rigour in qualitative research. As described earlier, the supervisory team acted as critical friends during the qualitative research, questioning, adding to, and refining interpretations of data. This dialogue with critical friends is an important aspect contributing to stronger qualitative rigour in the studies.

8.6.3 Supervision and steering group. The lead researcher (DS) is a yoga teacher. This aspect was recognised, and appropriate systems were put in place to

ensure that biases do not inadvertently seep into the research. The supervisory team were new to yoga, and could provide objective guidance on the PhD project. A steering group was set up, and while it included two yoga teachers to advise on elements specific to yoga, the group also included experts in the field of physical activity and a Surgeon at the Royal Infirmary Edinburgh. Constant engagement with members of the steering group also contributed to maintaining objectivity.

8.7 Next Steps for Intervention Development and Evaluation

Three intervention development frameworks were used in this thesis (Craig et al., 2013; Nutbeam & Bauman, 2014; Wight et al., 2016), and Figure 42 shows the status of the yoga programme development process (steps completed so far in the intervention development process), and charts out the future steps for development and evaluation. The 6SQuID framework (Wight et al., 2016) focuses exclusively on intervention development and as such five of the six prescribed steps have been completed. The MRC framework (Craig et al., 2013) and the evaluation cycle (Nutbeam & Bauman, 2014) go beyond development to include evaluation and implementation. Based on these frameworks the next steps for the developed programme have been specified (Figure 42).

The steps undertaken and completed in the intervention development process so far include:

(i) Defining and understanding the problem and its causes (Nutbeam & Bauman, 2014; Wight et al., 2016)

(ii) Identifying the evidence base (Craig et al., 2013; Nutbeam & Bauman, 2014)

(iii) Solution generation (identifying the process of change, and formative evaluation) (Nutbeam & Bauman, 2014; Wight et al., 2016)

(iv) Identifying theory/process of change and clarifying which factors have the greatest scope for change (Craig et al., 2013; Nutbeam & Bauman, 2014; Wight et al., 2016)

(v) Some testing and refining on a small scale/ modelling processes and outcomes (Craig et al., 2013; Wight et al., 2016)

Development and evaluation steps for the future include:
(i) Test and refine on a small scale (feasibility studies) (Craig et al., 2013; Wight et al., 2016)
(ii) Collect enough evidence of effectiveness to justify rigorous evaluation and implementation (Pilot study: randomised or non-randomised with outcome and process evaluation, resource mobilisation) (Craig et al., 2013; Nutbeam & Bauman, 2014; Wight et al., 2016)
(iii) Large scale rigorous evaluation with long-term follow-up (Craig et al., 2013; Nutbeam & Bauman, 2014)
(iv) Implementation and dissemination (Craig et al., 2013; Nutbeam & Bauman, 2014)

8.7.1 Test and refine on a small scale. Some formative evaluation has already been carried out in the current study. Further studies to refine the intervention could include understanding and incorporating components to address barriers to participation in lower socio-economic areas and inactive older adults. Yoga instructors delivering the final programme are required to provide alternative postures and modifications if participants are unable to perform certain postures. The intervention component on training for instructors recommends that training be provided for instructors on the appropriate modifications for specific health conditions. This was not within the purview of this PhD, but a synthesis of research conducted so far and further research to specify modifications and contraindications for each medical condition such as arthritis, COPD, high blood pressure etc could be undertaken. This could take the form of a systematic review to identify posture modifications in previous research studies, workshops with yoga instructors so that their knowledge and experience could help identify posture modifications for each health condition, focus groups with the target population to assess acceptability of the modifications, and RCTs to assess the effect of the developed programme (with posture modifications) on selected health outcomes.

There is also opportunity for the suggested strategies to encourage yoga to be explored in greater detail. For example, one strategy involved engaging healthcare

professionals so that they could recommend yoga to older adult patients when appropriate, and work with yoga instructors to highlight contraindications and reduce injuries. In reality, there are several barriers hindering healthcare professionals' engagement with PA promotion such as lack of time, education and resources (Savill, Murray, & Weiler, 2015). For similar reasons, they may not actively participate in yoga promotion. The feasibility of each of the suggested strategies could be studied further, and refined to enhance their effectiveness in promoting yoga among older adults.

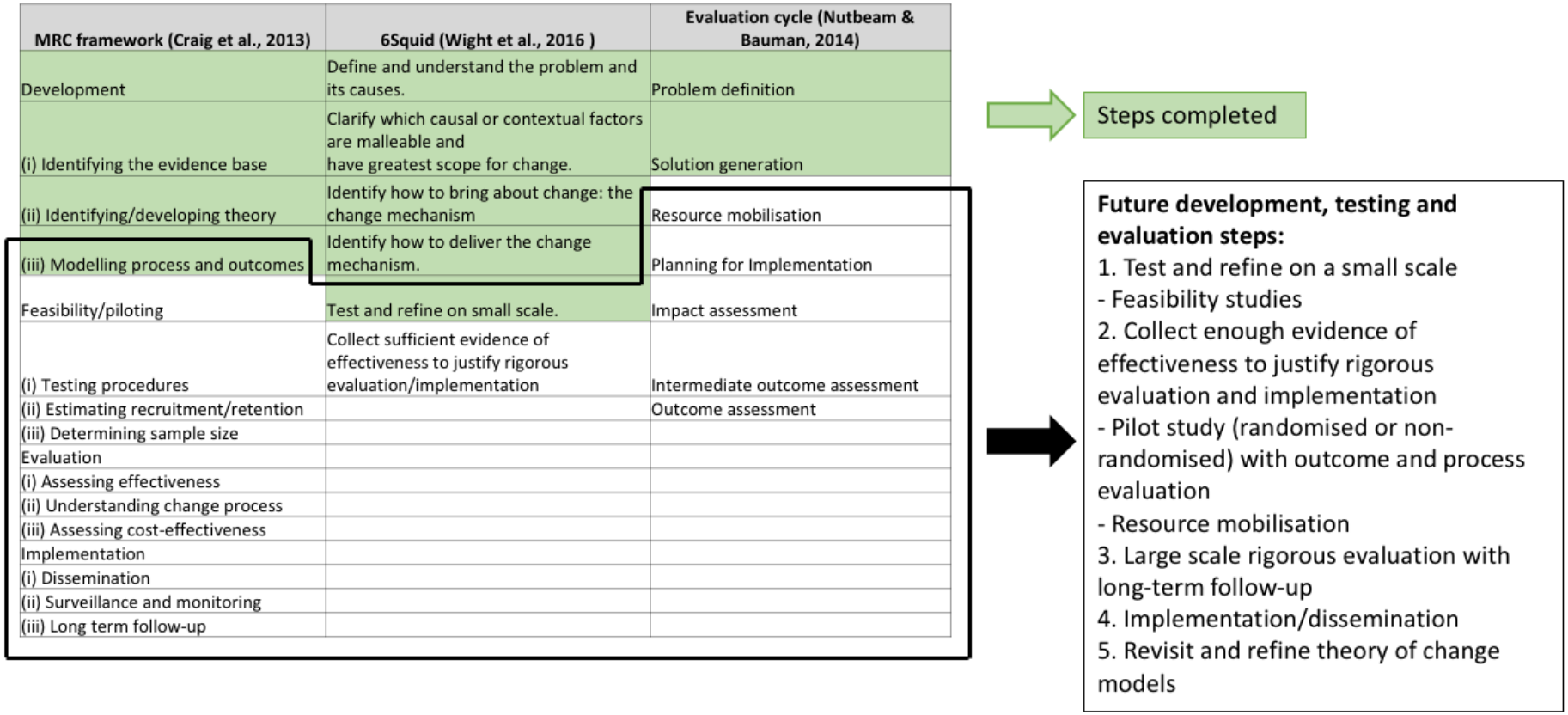


Figure 42. Intervention development steps completed and future development and evaluation

8.7.2 Collecting enough evidence of effectiveness to justify rigorous evaluation and implementation. This is the final step of intervention development in the 6SQuID process (Wight et al., 2016). The framework recommends ensuring that there is enough evidence to show that the intervention is effective in achieving short-term objectives such as recruitment and adherence to the yoga programme. It is also important to ascertain that there are no unintended consequences. For example, a participant in Study 3 mentioned that she substituted the home-based exercises for walking, and this unintended consequence of reduced aerobic activity has been addressed by an intervention component. This phase is extremely important before planning a large-scale evaluation. The MRC framework (Craig et al., 2013) recommends feasibility or pilot testing which aims to achieve similar objectives. This stage could involve testing data collection procedures, delivery of the yoga intervention, recruitment and retention, and estimating the sample size for a larger intervention. Pilot and feasibility studies are described in detail under the evaluation section.

This step could also include resource mobilisation which is the third stage in the evaluation cycle (Nutbeam & Bauman, 2014). Resource mobilisation deals with obtaining resources such as funding, staff and material for the successful implementation of the programme. This would mean ensuring that the right conditions for successful implementation are in place such as capacity building within the community and political support.

8.7.3 Evaluation. It should be noted that the recommended future steps are not linear, and steps could be revisited with constant adaptation and refinement of the yoga programme. Different evaluation processes could be conducted during the stages of formative evaluation, testing and refining, and collecting evidence to justify a large-scale intervention.

8.7.3.1 Feasibility studies. Eldridge et al. (2016) define feasibility studies (that are not pilots) as studies where the intervention or other processes such as recruitment or data collection are not implemented, but are still addressing some

aspects of intervention development. Focus groups, interviews and questionnaires, which were used in the current thesis are some suggested evaluation methods for feasibility studies. The 6SQuID framework (Wight et al., 2016) also recommend that if resources are limited, a before and after survey or using routinely collected data may be practical methods of collecting evidence of effectiveness. Research conducted to test and refine the intervention on a small scale could be undertaken as feasibility studies.

8.7.3.2 Pilot study. Once the programme is almost final, a pilot study could be conducted to ensure that the various programme components can be executed as planned. This could be a randomised or a non-randomised pilot study (Eldridge et al., 2016). Randomised pilot studies are smaller versions of the planned full-fledged RCT.

The MRC framework (Craig et al., 2013) stresses on the importance of randomisation as it would prevent selection bias in evaluation methods. RCTs have been ranked the second best type of evidence in evaluating the effects of an intervention, surpassed only by systematic reviews of RCTs (OCEBM Levels of Evidence Working Group, 2011). Studies with a non-randomized design introduce an upward bias by overestimating the effects of healthcare (Sacks, Chalmers, & Smith, 1982).

Sherman (2012) prescribed some guidelines to be observed while preparing a yoga intervention for evaluation as an RCT. These guidelines pertained to yoga as a treatment for clinical conditions, but can be consulted while evaluating a yoga interventions for older adults. The domains to be addressed while planning the evaluation process, and how the current study addresses these are described-

1. Style of yoga: Sherman (2012) suggested that the yoga style selected for a research study should be safe and appropriate for the target population. In this PhD thesis, no specific style has been suggested, and the instructor is given the opportunity to integrate the components within their own style of yoga. This would also make it easier during the implementation of the intervention

on a large scale, as instructors are not forced to adopt or be trained in a specific style.

2. Dose of yoga: Sherman (2012) acknowledged the lack of evidence on the optimal frequency, duration and length of yoga interventions. This PhD thesis has identified the frequency preferred by older adults as one or two days a week, and average duration as 60 minutes, with activity for approximately 50 minutes. While designing the RCT, depending on time and resources, the length of intervention should also be specified.
3. Components of the yoga intervention should be specified: The eight limbs of yoga were introduced in Chapter 1 (section 1.12). Sherman (2012) emphasised that it is important to clarify which of these will be included in the yoga programme. Detailed intervention components have been provided in the current PhD programme with focus on postures, breathing and some meditative aspects.
4. Specific class sequences: Sherman (2012) reported that yoga interventions are not usually described in detail in research studies, and raised questions around the use of standardised protocols versus allowing instructors to choose from a menu of options. While standardisation is more reproducible, it could constrain instructors and limit creativity and engagement. The difficulty in incorporating progressiveness and variety within a fixed protocol was also mentioned by Sherman (2012). For these reasons and to ensure that instructors assume an active role in the delivery of the intervention, the current study provides examples of postures (section 6.3.2, Figure 34), but does not have a rigid schedule.
5. Modifications: Offering modifications if participants are not able to perform certain postures was noted as important even if a standardised protocol is followed (Sherman, 2012). The current study emphasises the need for posture modifications. However, the modifications have not been defined. Further research to specify possible alternatives for each posture is required (section 6.3.4.1).
6. Instructors: The qualification and competency of instructors was highlighted as critical for achieving study outcomes (Sherman, 2012). The current

programme provides detailed guidance for instructors and emphasises providing adequate training on working with older adults.

7. Home practice: It was suggested that if home practice is a part of the intervention then appropriate aids such as home practice books, DVDs and internet material should be provided (Sherman, 2012). In the current study preferences of older adults with respective to home-based yoga practice were examined and components addressing this have been provided.
8. Measurement of intervention fidelity over time: Finally, it was recommended that intervention fidelity (have the core features of the intervention been delivered as intended?) should be evaluated (Sherman, 2012). Observing classes to ensure that instructors are delivering classes as intended, and developing checklists to capture all intervention components of the programme was suggested. For the current yoga programme, intervention fidelity was enhanced by briefing the instructor (in person and providing resources) prior to the taster session. The programme was refined based on instructor feedback to improve fidelity during future testing.

A criticism of this paper is that no information was provided on how these domains were arrived at. However, the author has referred to clinical trials on yoga for cardiovascular risk factors and disease, cancer, back pain and other conditions while providing information on these domains. The domains mentioned above can be used as a checklist during the design of an evaluation protocol.

In non-randomised pilot studies, all or parts of the intervention and other processes such as recruitment and collection of outcome data are carried out on a smaller scale but without randomisation of participants (Eldridge et al., 2016). These could also include studies where only the intervention is piloted and no other trial processes are undertaken. Quasi-experimental designs (which have a control group to which participants are not randomly assigned) and pre-post study designs (which have no control group, and outcome data is collected from one group before and after the intervention) could be adopted (Nutbeam & Bauman, 2014). These designs have their limitations and observed changes in the intervention group could be caused by factors other than the intervention. They are however practical and can provide

valuable information on recruitment, delivery and data collection (Nutbeam & Bauman, 2014). Time and availability of funding are important in the selection of the study design.

The pilot study could include process evaluation, and outcome or impact evaluation (Nutbeam & Bauman, 2014). Process evaluation involves the assessment of activities surrounding the programme, such as whether the target population were aware of messages being communicated and whether they received the programme, recruitment activities, programme delivery or fidelity, whether participants used the resources, attended classes and whether the programme met their needs. Outcome or impact evaluation include the measurement of short-term health promotion outcomes that are predicted in the planning stages of development.

A mixed method approach could be adopted for process and outcome evaluation. Quantitative and qualitative methods are recommended within the pilot study for a comprehensive evaluation of outcomes and processes (Nutbeam & Bauman, 2014). Outcome data on physical function and HRQoL could be collected and assessed quantitatively. Based on the systematic review (Study 1), recommended physical function outcomes to be measured are body composition measures, cardio-respiratory fitness, strength (lower and upper limb strength, hand grip strength), flexibility (lower and upper body flexibility, range of motion), mobility, walking speed, balance, and fall frequency; HRQoL measures are anxiety, depression, perceived physical health, perceived mental health, vitality, social health, sleep quality, stress, fear of falls, and balance confidence. Focus groups and interviews are appropriate methods to collect qualitative data from participants to evaluate whether the intervention components have been successful in increasing appeal, appropriateness and acceptability. Observation or video recording of the intervention could be implemented to assess intervention fidelity. Assessing intervention fidelity would help record the variations in delivering the intervention and determine if further standardisation is required (Craig et al., 2013). Evaluation procedures should aim to assess intermediate and final outcomes as described in the theory of change models.

It is also important to understand cost-effectiveness of the intervention. For controlled trials, cost effectiveness of the intervention against the control could be estimated.

As an example, the suggested method for assessing cost-effectiveness in the REtirement in ACTion (REACT) study was to estimate costs associated with intervention delivery, and participant level costs associated with health and social care resource use, through self-report over the intervention and follow up period (Stathi et al., 2018). Quality-adjusted life years (QALYs) can be estimated from EuroQoL five dimension five level (EQ-5D_5L) data reported by participants. Cost-effectiveness analyses (CEA) would compare estimated costs and QALYs, as well as incremental cost and QALYs.

8.7.4 Large rigorous evaluation and implementation. The programme could be further refined based on the feasibility and pilot studies. Once there is enough evidence, a large scale RCT spanning a wider geographical area and including cities across Scotland such as Glasgow, Aberdeen, Dundee and Stirling could be carried out. This would also include process and outcome evaluation, as well as assessment of cost-effectiveness as described above (section 8.7.3.2). It is important to have a long follow-up period (Craig et al., 2013) and examine regularity and maintenance of class-based and home-based yoga practice. Long-term is generally described as greater than 12 months (Finnegan, Seers, & Bruce, 2018; Harris et al., 2018), with several studies evaluating long-term effects of PA interventions 2- 4 years from the baseline (Gray et al., 2018; Hall et al., 2011; Harris et al., 2018).

The intervention and processes would need to be refined at each stage of evaluation, based on results. There is potential for dissemination of the programme and roll-out across Scotland following a successful large-scale evaluation. Recommended dissemination processes include:

1. Providing yoga teachers and studios detailed information on the developed yoga programme. Since the programme is complex with some contradicting and controversial components (such as reduced spiritual content), a workshop

and dialogues with instructors is preferred to a simple checklist format.

2. Integrating components into yoga teacher training conducted in Scotland
3. If funding is available, surveillance and monitoring processes similar to a large scale RCT could be set up to collect process and outcome evaluation data. If this option is unrealistic, it is recommended that routinely collected information such as new members, attendance, adverse events, and simple surveys to assess participant satisfaction could be collected.
4. Setting up yoga network groups with regular meetings among instructors to share instructor experiences from working with older adults so that new insights are collected and shared, and the programme is constantly improved.
5. Working with yoga teachers, yoga schools, community leisure centres, charities, healthcare professionals and the Scottish government to implement strategies to promote yoga. Promoting yoga needs to be a multi-pronged approach where all suggested strategies are simultaneously explored. The Government plays an important role in PA promotion, and government policies and messages have the power and authority to influence the public. For example, the Indian Prime Minister has been an active advocate of yoga and performed yoga with 50,000 volunteers on International Yoga Day in 2018. An Indian minister for yoga has also been appointed. The Scottish Government has made great progress in the area of PA promotion in recent years (Scottish Government, 2018), and it is crucial to partner with the government to promote yoga. In October 2018, a yoga teacher, Lindsey Porter organised a session at the Scottish Parliament in Edinburgh, in conjunction with SAMH (Scottish Association for Mental Health) to celebrate signing up to the Scotland's Mental Health Charter for Physical Activity and Sport, and, raise awareness of the benefits of yoga. Several yoga practitioners shared their experiences of yoga and its positive impact on mental wellbeing. This is a great example of engaging multiple stakeholders, and gaining their support to promote yoga. Working with yoga teachers and representatives such as Lindsey Porter (YOGA-NU-U: http://www.yoganuu.com/), Lorraine Close (Edinburgh Community Yoga), June Adamson (Yoga Instructor, Quality Assurance & Training, Centre for

Sport and Exercise, University of Edinburgh) and Claire Craig (Health & Physical Activity Manager, Edinburgh Leisure) and leveraging their passion and networks is key to promoting yoga among older adults.

8.7.5 Iterative theory of change models. Nutbeam and Bauman (2014) emphasise the importance of developing theory of change models early in the process of intervention development as it allows the developer to "structure the various sources of information that have informed the development of the intervention, and then to consider in a logical sequence the likelihood of achieving the programme goals and objectives through each step and strategy planned for the programme" (Nutbeam & Bauman, 2014, p.39). As suggested by Funnell and Rogers (2011), it is important to revisit the proposed frameworks when there are changes to the research evidence or knowledge base on which the theory of change framework is based. The initial model suggested in the PhD was expanded based on the results of the studies conducted as a part of this PhD and it is recommended that the framework is revisited and revised during every stage of the evaluation process (testing and refining, large scale evaluation). A process evaluation will provide information on the delivery of the programme, help identify programme components that were successful in achieving the outputs and intermediate outcomes, and provide an understanding of why the programme did or did not perform as expected (Craig et al., 2013). This information would significantly influence the theory of change models and should be considered while refining the models.

The yoga intervention has not aligned itself with any particular behavioural theory at this stage, and this could be further explored during testing and refining stages. For example, Self-determination theory was identified as a potential explanatory framework in Chapter 2, and future iterations could examine the merits of aligning the intervention to this framework. SDT could be integrated as a behavioural theory nested within the overall theory of change model for the yoga programme.

To summarise, based on the above discussion it is recommended that future research explores (Figure 42):

1. Feasibility studies:

(i) Understanding of the barriers and preferences to yoga practice among inactive older adults or those belonging to lower socio-economic categories

(ii) Posture modifications for various clinical conditions to be compiled from previous research and tested and refined in conjunction with older adults

(iii) Further strategies to promote yoga

2. Pilot study

(i) This could be randomised or non-randomised pilot studies with process and output evaluation. Estimation of sample size for a larger trial will be undertaken at this stage. Outcome evaluation and process evaluation should be undertaken.

(ii) Resource mobilisation will also need to be carried out such as organising funding, scouting for the right partners, yoga instructors and studios, and development of material for home-based yoga practice.

3. Large scale RCT with a long-term follow-up

4. Implementation/dissemination of the yoga programme over a wider geographical area in Scotland.

5. Revisit and revise theory of change models during the course of the evaluation process.

8.8 Applications

A significant recommendation from the systematic review (Study 1) was to continue to promote yoga in the PA guidelines as a MS, and BC activity. Although the aim of this thesis was to develop a yoga programme for older adults in Scotland, the intervention components would be useful at a global level. Findings from the study such as guidance to instructors, details on nomenclature, class environment, and preferred frequency and duration would be of value to yoga instructors,

programme developers and studio owners. There is great emphasis on understanding the barriers to participating in yoga, since one of the biggest challenges is inducing people to join and regularly attend group classes or continue home practice (Singh Khalsa et al., 2016). The suggested strategies to promote yoga would aid recruitment to a yoga class or research studies. Taster sessions, leaflets and home-based handouts were found to be effective in providing information on yoga. These could be adopted by yoga studios and fitness centres, and they could use older adults' feedback on the leaflet (Study 3) in the development of promotional material.

This PhD project is the first step in the development and evaluation of an appealing, appropriate and acceptable yoga programme for older adults in Scotland, with the ultimate goals of increased adherence to MS and BC guidelines, and improved physical function and HRQoL.

8.9 Conclusion

This is a novel project using intervention development frameworks to design an appealing, appropriate and acceptable intervention for older adults in Scotland. The project also identified strategies to promote yoga in this population. The intervention components address several aspects of a yoga programme, and incorporate insights gathered from consultations with stakeholders including older adults and instructors. As a part of the intervention development process, some feasibility testing has been carried out and theory of change models to understand how the programme would work have been developed. Findings from this study would be of value to yoga teachers, programme developers, studios and fitness centres, and researchers. The development and evaluation process should be continued so that rigorous testing to ensure effectiveness is carried out before implementation.

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Glossary of Yoga Postures

Yoga postures can be grouped under some broad categories:

(i) Standing postures: These are executed while standing. Example: tree pose

(ii) Sitting postures: These postures assume a seated position. Example: the cow face pose

(iii) Supine postures: These are done lying on the back with the face up. Example: wind relieving pose

(iv) Prone postures: These are done lying on the stomach. Example: cobra pose

(v) Twists: These poses involve twisting (usually the spine), and can be done standing, seated or lying down Example: half fish pose

(vi) Back bends: These are postures that curve the back, so as to open the chest and stretch the abdomen. Example: upward dog pose

(vii) Forward bends: These postures involve folding forward and are described as passive stretches that utilise gravity. Example: Hands touching toes/ hand to foot pose

(viii) Inversions: These are poses where the heart is at a higher level than the head. These could include advanced poses such as the headstand, and easier poses such as the downward dog pose

Postures can fall under multiple categories. Some poses mentioned in the thesis are illustrated below. These have been included as a rough indication of what the pose would involve, and may not be anatomically accurate.

Illustration of some common poses mentioned in the thesis

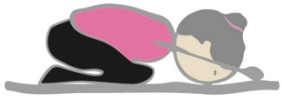
Wind relieving pose

(One leg)

Wind relieving pose

(both legs)

Child's pose



Hands touching toes

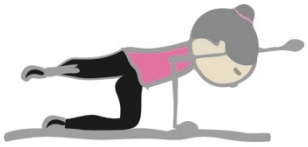
Tree#2

Halfway forward bend

Upward dog

Cow face

Bird dog

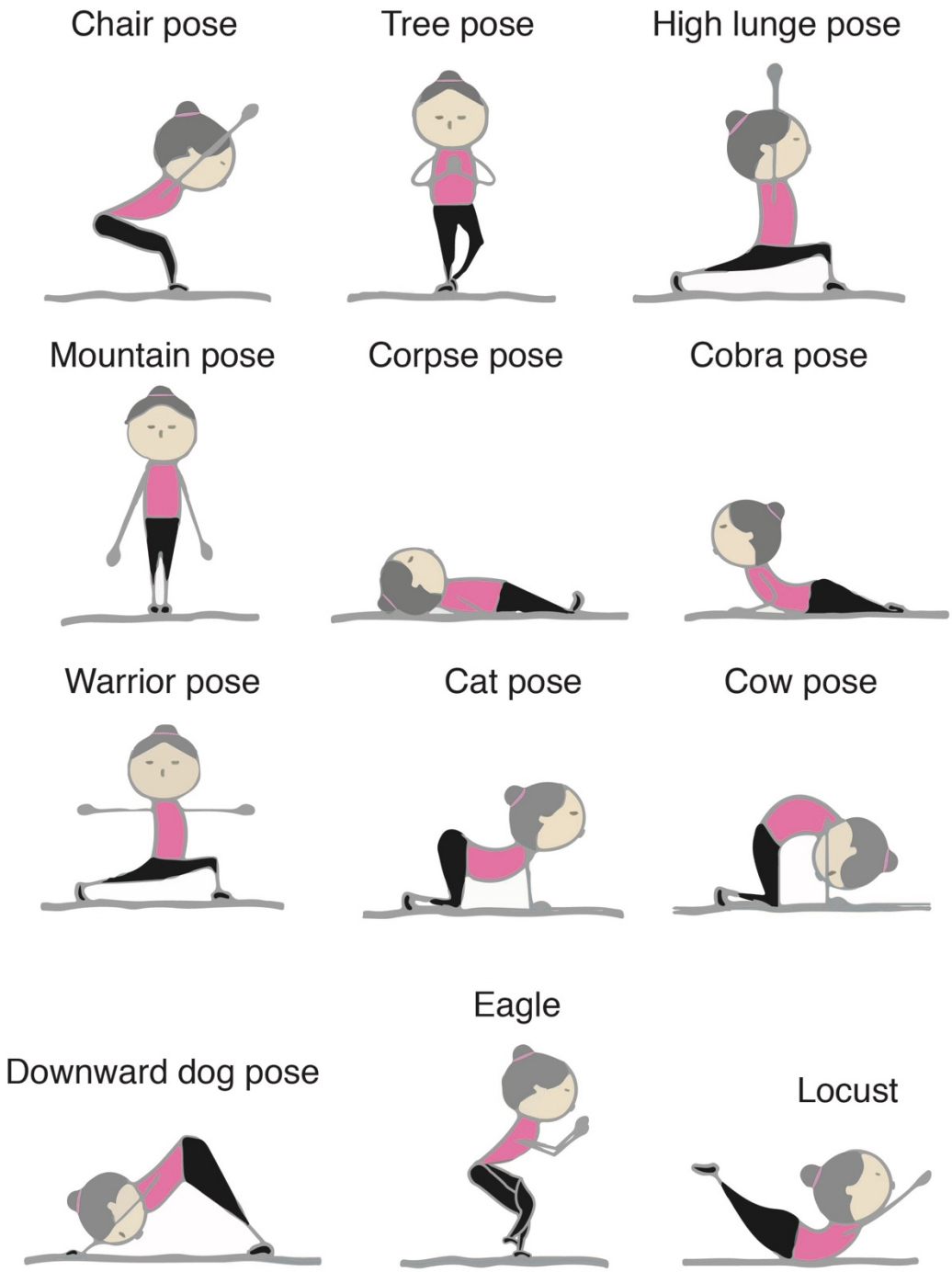


Triangle

All 4 knee lift

One leg balance

Illustration of some common poses mentioned in the thesis (continued)



Appendices

Appendix 1. Items from the toolkit of adaptation approaches

Items from the Tool Kit of Adaptation Approaches relevant during the conceptualisation and planning stage of the intervention (Davidson et al., 2013)

Collaborative Working

1. Exploratory phase with target population (same group as intervention group)
2. Exploratory phase with target population (different group than intervention group or cannot tell)
3. Exploratory phase with community leaders

Team

9. Ethnically matched high-level/respected individuals and community members throughout planning, directing, reviewing, and implementing stages
10. Ethnically matched leadership within the study
11. Cross-cultural training for all study personnel

Endorsement

13. Ethnically matched high-level/respected individuals to increase salience of program goals
14. Utilizes local/respected religious/spiritual leaders
15. Collaboration with ethnic specific institutions and professional organizations
16. Utilizes ethnically appropriate informal networks

Materials

23. Materials developed specifically for target population (by project investigators, expert opinion, tools)
24. Materials created by members of the target population

Messages

31. Addresses concerns with medical programs, procedures, and medication

35. Addresses discrimination and mistrust

Delivery

45. Purposefully maintains an exclusive or open intervention environment as preferred by target population

46. Gender taken into consideration

Sivaramakrishnan et al. International Journal of Behavioral Nutrition and Physical Activity (2019) 16:33
https://doi.org/10.1186/s12966-019-0789-2

International Journal of Behavioral Nutrition and Physical Activity

REVIEW Open Access

The effects of yoga compared to active and inactive controls on physical function and health related quality of life in older adults- systematic review and meta-analysis of randomised controlled trials

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Abstract

Background: Yoga has been recommended as a muscle strengthening and balance activity in national and global physical activity guidelines. However, the evidence base establishing the effectiveness of yoga in improving physical function and health related quality of life (HRQoL) in an older adult population not recruited on the basis of any specific disease or condition, has not been systematically reviewed. The objective of this study was to synthesise existing evidence on the effects of yoga on physical function and HRQoL in older adults not characterised by any specific clinical condition.

Methods: The following databases were systematically searched in September 2017: MEDLINE, PsycInfo, CINAHL Plus, Scopus, Web of Science, Cochrane Library, EMBASE, SPORTDiscus, AMED and ProQuest Dissertations & Theses Global. Study inclusion criteria: Older adult participants with mean age of 60 years and above, not recruited on the basis of any specific disease or condition; yoga intervention compared with inactive controls (example: wait-list control, education booklets) or active controls (example: walking, chair aerobics); physical function and HRQoL outcomes; and randomised/cluster randomised controlled trials published in English. A vote counting analysis and meta-analysis with standardised effect sizes (Hedges' g) computed using random effects models were conducted.

Results: A total of 27 records from 22 RCTs were included (17 RCTs assessed physical function and 20 assessed HRQoL). The meta-analysis revealed significant effects (5% level of significance) favouring the yoga group for the following physical function outcomes compared with inactive controls: balance (effect size (ES) = 0.7), lower body flexibility (ES = 0.5), lower limb strength (ES = 0.45); compared with active controls: lower limb strength (ES = 0.49), lower body flexibility (ES = 0.28). For HRQoL, significant effects favouring yoga were found compared to inactive controls for: depression (ES = 0.64), perceived mental health (ES = 0.6), perceived physical health (ES = 0.61), sleep quality (ES = 0.65), and vitality (ES = 0.31); compared to active controls: depression (ES = 0.54).

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Conclusion: This review is the first to compare the effects of yoga with active and inactive controls in older adults not characterised by a specific clinical condition. Results indicate that yoga interventions improve multiple physical function and HRQoL outcomes in this population compared to both control conditions. This study provides robust evidence for promoting yoga in physical activity guidelines for older adults as a multimodal activity that improves aspects of fitness like strength, balance and flexibility, as well as mental wellbeing.

Trial registration: PROSPERO registration number: CRD42016038052.

Keywords: Physical activity, Strength, Balance, Flexibility, Wellbeing, Depression, Sleep, Vitality

Background

The World Health Organization's physical activity (PA) recommendations for older adults (aged 65 years and over) include aerobic, muscle strengthening and balance components [1]. Physical activity levels worldwide decrease with age [2], and the percentage of older adults meeting these recommendations remains low. The United Kingdom (UK) PA guidelines for this age group include the accumulation of at least 150 min of moderate intensity activity or 75 min of vigorous activity per week (MVPA guidelines), as well as activities to improve muscle strength, and balance and coordination on at least two days a week [3]. Thirty-one percent of adults aged 65–74 years and 54% of adults aged 75+ years in England (2015–2016) [4], and 53% of men and 66% of women aged 65 years and over in Scotland (2012–2014) [5], did not meet the MVPA guidelines. The balance guidelines were met by 19% of older men and 12% of older women in Scotland [6]; and only 14% of men and 12% of women in the 65–74 age-group, and 9 % of men and 4 % of women over 75 years met the muscle strength guidelines [6]. Accordingly, the World Health Organization identifies older adults as a strategic priority area for the promotion of physical activity [7].

Yoga is an ancient practice and a way of life that originated in India, and includes the practice of postures, regulated breathing and meditation [8]. It is a mode of activity found to have multiple benefits for older adults [9–11]. Previous systematic reviews have provided evidence on the beneficial effects of yoga in older adults in terms of promoting cardiovascular health [12], balance and mobility [10], alleviating depression and improving quality of sleep [9]. A recent systematic review and meta-analysis by Tulloch et al. [13] found that yoga had a medium effect on health related quality of life (HRQoL), and a small effect on mental wellbeing in people aged 60+ years. In this review, HRQoL was measured by physical component summary scales, and mental wellbeing was assessed by mental component summary scales from questionnaires like SF-36 and WHOQOL. However, HRQoL has been described as a concept encompassing several aspects of overall quality of life that can be clearly shown to affect health [14], including anxiety, stress, depression, vitality, social health and sleep [15], which were not assessed in the review.

Physical function is another relevant outcome for the older adult population and includes aspects such as cardio-respiratory fitness, muscular strength, flexibility and balance [16, 17]. Benefits of performing muscle strength activities in older adults include the offsetting of age-related muscle loss (sarcopenia), enhanced functional performance, improved bone mineral density (BMD), and prevention of falls [18, 19]. Whilst yoga has been specifically recommended as a muscle strengthening activity as part of several national PA guidelines including the UK and United States (US) [20, 21], there have been no previous attempts to synthesise the evidence base to support this recommendation for the older adult population. Patel et al. [11] studied the effects of yoga on some physical function and HRQoL outcomes in older adults from randomised controlled trials (RCT) published between 1950 and 2010. Results of the meta-analysis showed that yoga may be significantly better than controls in improving self-rated health status and aerobic fitness, but no significant differences were found for depression. However, the narrative and quantitative analysis in the Patel et al. review [11] combined data in which yoga was compared with active (example: walking, Tai chi, stretching exercises) and inactive controls (example: usual care, socialisation, education group), making it difficult to draw conclusions on whether any true effects (statistically significant) of yoga compared to other exercise programmes exist, and the strength (magnitude) of these effects.

Tulloch et al. [13] and Patel et al. [11] included studies involving older participants with clinical conditions. Other systematic reviews have focused on yoga in specific clinical groups such as cancer [22], Type 2 Diabetes [23, 24] and rheumatic diseases [25], and found some evidence that yoga has beneficial effects on physiological, physical function and psychosocial outcomes in these populations. Results from studies which only recruited participants with specific diseases or conditions cannot be generalised to all older adults. The yoga interventions used in studies involving clinical populations may have

been specially developed to address particular symptoms (example: dyspnea related distress in older adults with chronic obstructive pulmonary disease [26]). It is also difficult to disentangle the effects of yoga when data from heterogeneous groups with different clinical conditions are merged in a review.

Therefore, the present systematic review aims to address limitations in previous reviews and expand on existing evidence in three ways: i) including a comprehensive list of physical function and HRQoL outcome measures; ii) comparing yoga against distinct active and inactive controls so that the relative benefits of yoga can be assessed; and iii) reviewing the effectiveness of yoga in studies where older adult participants were not recruited on the basis of a specific disease or condition. The objective of this review was to assess the effectiveness of yoga compared to active and inactive controls on physical function and HRQoL in older adults not characterised by a specific clinical condition, based on randomised/cluster randomised controlled trials.

Methods

The review was conducted in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [27], and recommendations of the Cochrane collaboration [28]. The protocol was developed in advance of the study and registered on PROSPERO (Registration number: CRD42016038052).

Search and selection criteria

The inclusion and exclusion criteria for studies were as follows: (i) Participants: older adults defined as mean age 60 years and above, not recruited on the basis of a specific disease or condition were included; (ii) Intervention and comparison: studies comparing yoga interventions with active and inactive controls were included. Studies in which yoga was specified as a control condition or where yoga was combined with other practices or exercise forms were excluded; (iii) Outcomes: only studies reporting physical function and/or HRQoL outcomes were included; (iv) Study type: studies with a randomised (including cluster randomised) controlled study design published in English were included.

A mean age of 60 years and above was a criterion for inclusion. The retirement age in countries like India and China is 60 years [29, 30], and the United Nations defines older persons as those aged 60 years or over [31]. To accommodate these definitions of old age, the age criterion for inclusion in this review was set as a mean of 60+ years. Another criterion was the inclusion of participants who were not recruited based on a disease or condition, and this meant excluding studies in which participants were recruited specifically if they had a particular disease or clinical condition. However, studies with frail, inactive older adults, and those with poor balance were included in the review.

Studies with yoga as a control group were excluded from the review ($n = 6$) [32–37]. In these studies, the yoga group was used to control for aspects such as social stimulation and attention from trainers, without producing an aerobic response. The reporting for the controls was not rigorous, and the yoga programmes were not described in detail. Some studies dated back to 1989, making it difficult to procure the necessary data for them.

Search and screening

Database searches were conducted in September 2017. The following databases were searched (from inception till September 2017): Medline, PsycInfo, CINAHL Plus, Scopus, Web of Science, Cochrane Library, Embase, SPORTDiscus, AMED, ProQuest Dissertations & Theses Global. The search was conducted using key words related to "yoga" and "older adults". A detailed list of the search terms used is presented in the supplementary section (Additional file 1). The outcome and study type criteria were applied at the screening stage. The reference lists of included studies were also checked for additional relevant studies [38].

Screening was carried out in three stages using reference management software (EndNote X7.2.1). First, a preliminary title and abstract screening was performed by one researcher (DiS) where duplicates and obviously irrelevant studies were removed. Five percent of the search results were cross-checked by another researcher (KL). Second, titles and abstracts of all studies were screened by two researchers (DiS, KL) with studies categorised as "Yes" (satisfied eligibility criteria), "No" (did not satisfy eligibility criteria) and "Maybe" (uncertain, and need further scrutiny). Finally, full texts of studies in the "Yes" and "Maybe" categories were screened in further detail by two researchers (DiS, KL). Disagreements were resolved by a third researcher (CF or GB).

Data extraction

A custom data extraction form for descriptive characteristics (Additional file 2) was developed and piloted by three researchers (DiS, GB, CF). Descriptive data were extracted for all included studies by one researcher (DiS), and 33% of these were cross-checked by another researcher (GB or KL). Outcome data were extracted by one researcher (DiS), and 100% cross-checked by another researcher (KL). Discrepancies were resolved through discussions among the researchers (DiS, KL). Authors of studies for which outcome data were not available were contacted and requested to provide the data, and were asked for clarifications if required. One study only reported median, minimum and maximum

values for outcome variables [39]. Means and standard deviation were imputed from these data [40–42], and the study was included in the meta-analysis.

Quality assessment

Risk of bias was assessed independently by two researchers (DiS, KL) using the Cochrane risk of bias tool [43]. The following domains were assessed for physical function and HRQoL outcomes separately: selection bias (random sequence generation, allocation concealment), detection bias (blinding of outcome assessment), attrition bias (incomplete outcome data), reporting bias (selective reporting), and other bias (sample selection bias [44–47], contamination bias [45, 46], compliance bias [46] and response bias [48]). Performance bias (blinding of participants and personnel) was not assessed as it is impossible to blind participants and personnel in a yoga intervention study. Under each domain, studies were classified as low, high or unclear risk of bias. Discrepancies were resolved through discussion between the two researchers.

Analysis

For the physical function and HRQoL variables, separate analyses comparing yoga with active and inactive groups were conducted. Other sub-group analyses such as types of yoga and gender were not explored. Though different yoga types have been used in the included studies, there is similarity between types in terms of the structure and postures followed and hence, it was not considered appropriate to compare them. Further, the requisite outcome data were not readily available by gender for a majority of studies.

Vote-counting

As a preliminary analysis, a 'vote counting' approach was adopted [49], where three categories were created for each outcome: statistically significant (as reported by authors) positive effects favouring the yoga group, statistically significant negative effects (i.e., favouring the control group), and no significant difference between groups. For every outcome, effects of yoga was based on the category with the highest number of vote counts. For example, for strength, if the majority of studies found significant positive results favouring yoga, then yoga was considered to have a positive effect [49]. Vote-counting has been critiqued as crude and flawed as it does not give due weight to sample size and effect size (ES). However, when used in conjunction with a meta-analysis, the method can provide a comprehensive understanding of the studies and outcomes included, and the effects of the intervention [49]. The vote-counting approach helped create a catalogue of all results from every study included in the systematic review, providing a foundational structure based on which the data for the meta-analysis were generated. The vote counting analysis included all outcomes assessed by more than one study, and the included outcomes are presented in Table 1.

Meta-analysis

For outcomes where quantitative data from three or more studies were available, a meta-analysis was conducted using the Comprehensive Meta-Analysis Version 3, Professional software. The outcomes included in the meta-analysis are presented in Table 1. Some studies used more than one test or instrument to measure an outcome. Since only one of these could be included in the meta-analysis, the test most commonly reported by the included studies was chosen. For balance, only functional assessments [50] such as one leg stand test, Berg balance scale, standing balance tests from the Short Physical Performance Battery, and Performance Oriented Mobility Assessment (POMA) were included in the meta-analysis. Objective measures like static and dynamic posturography [50] were not included due to the lack of a composite index and difficulties in interpreting the data. A random effects model was used as it better models data from heterogeneous populations [51]. Data at pre-intervention and immediately following the intervention were analysed, and effect sizes were calculated based on change (post minus pre) scores. Since various different instruments and units were used by studies to measure outcomes, calculation of mean differences was not possible, and standardised mean differences (SMD) were computed instead [51]. Hedges' g statistic was used to compute effect sizes, and Forest plots were created with 95% confidence intervals (CI). Effect sizes were categorised as small (0.2 to 0.5), moderate (0.5 to 0.8) and large (> 0.8) using Cohen's categories [52]. Statistical heterogeneity between studies was assessed using the I^2 statistic. Heterogeneity was categorised as low (I^2 = 0 to 40%), moderate (I^2 = 30 to 60%), substantial (I^2 = 50 to 90%) and considerable (I^2 = 75 to 100%) [51].

One study had two yoga intervention groups and one control group [53]. Both yoga groups were included in the meta-analysis, each one compared with half the number of participants in the control group [54]. Four studies [55–58] had one yoga intervention group and two control groups. In these cases the result was included twice in the meta-analysis with half the number of participants for the yoga group each time [54]. Following this, two sensitivity analyses were also conducted: (i) comparing the full yoga intervention arm and the first control group, and (ii) comparing the full yoga intervention arm and the second control group. Five included studies [53, 57, 59–61] used cluster randomisation, and an iteration of the meta-analysis was run after adjusting

Table 1 List of outcomes included and not included in vote-counting and meta-analysis

Analysis	Active/inactive control group	Physical functioning outcomes	HRQoL outcomes
Vote counting analysis	Yoga vs inactive controls	Body composition measures (body mass index (BMI), body weight, body fat percentage, waist circumference), cardio-respiratory fitness, strength (lower and upper limb strength, hand grip strength), flexibility (lower and upper body flexibility, range of motion (ROM)), mobility, walking speed, balance, fall frequency	Anxiety, depression, perceived physical health, perceived mental health, general health and wellbeing (subscale from SF-12 and SF-36), vitality, quality of life, social health, sleep quality, stress, fear of falls, balance confidence
	Yoga vs active controls	Strength (lower and upper limb strength), flexibility (lower and upper body flexibility), mobility, walking speed, balance, fall frequency	Anxiety, depression, perceived physical health, perceived mental health, vitality, stress
Meta-analysis	Yoga vs inactive controls	Body composition (BMI, body weight and body fat percentage), balance, lower body flexibility, upper body flexibility, walking speed, lower limb strength	Depression, fear of falls, perceived mental health, perceived physical health, sleep quality, social health, vitality
	Yoga vs active controls	Balance, lower body flexibility, lower limb strength, mobility, walking speed	Anxiety, depression, perceived mental health
Not included in vote-counting or meta-analysis (measured by just one study)	Yoga vs inactive controls		Anger [63], self-control [63], fatigue [64], motivational factors to exercise [55], pain [71], mood [64], hope [65], medication usage [66], capacity for self-care [66], self-efficacy (general, and for chronic disease) [63]
	Yoga vs active controls	Cardio-respiratory fitness [72]	Anger [63], self-control [63], fatigue [64], motivational factors to exercise [55], pain [71], mood [64], social health [64], general health and well-being [64], quality of life [71], balance confidence [67], fear of falls [67], self-efficacy (general, and for chronic disease) [63]

the number of participants in the studies to account for this (adjusted sample size = original sample size /design effect, where design effect = 1+ (Average cluster size - 1)*Intracluster Correlation Coefficient; calculations presented in Additional file 3) [54]. Four studies [53, 59–61] had the requisite data for cluster randomisation adjustment, and one study [57] was removed from this analysis due to lack of data. There were insufficient studies (less than 10) in the meta-analyses to test for publication bias using funnel plots [62].

Results

7996 records were identified through the data searches, and after the three stages of screening, 27 records from 22 RCTs (Fig. 1) were included in the systematic review. Seventeen RCTs with 967 participants assessed physical function, and 20 RCTs with 1567 participants assessed HRQoL.

Study and participant characteristics (Table 2)

Ten studies were from the USA [55, 56, 63–70], four from Australia [39, 71–73], two from Taiwan [53, 59], two from India [57, 74], and one each from Brazil [75], Iran [76], UK [77] and Portugal [78]. The number of participants in studies ranged from 18 to 410, and the mean size was 77 ± 84.

The mean age of participants in the studies ranged from 61.0 years to 83.8 years. In 15 studies, more than 70% of the participants were female. The attendance rates for class-based yoga sessions ranged from 67 to 100%, and for active controls it was 62 to 91%. Four studies reported adverse events in the yoga group (groin muscle strain [64], fall during yoga session [71], and musculoskeletal pain [73, 77]). Four studies reported that there were no adverse events during the course of the yoga intervention [53, 59, 68, 69].

Intervention characteristics

Eight types of yoga (Table 3) were used in the studies including Hatha yoga (4 studies) [67–69, 76], chair yoga (3 studies) [55, 63, 78], Iyengar yoga (3 studies) [39, 64, 73], Silver Yoga (2 studies) [53, 59], The Easy Does It Yoga Programme (2 studies) [66, 70], balance yoga programme [56], Thai Yoga [72] and the British Wheel of Yoga (BWY) Gentle Years Yoga programme [77]. Five studies did not mention the type of yoga programme conducted [57, 65, 71, 74, 75]. The most common class structure for the yoga intervention adopted by included studies was a warm up, followed by the main postures, and ending with relaxation, breathing and meditation. Some common postures (used in four or more included studies) are: Cat and cow pose, Tree position, Triangle

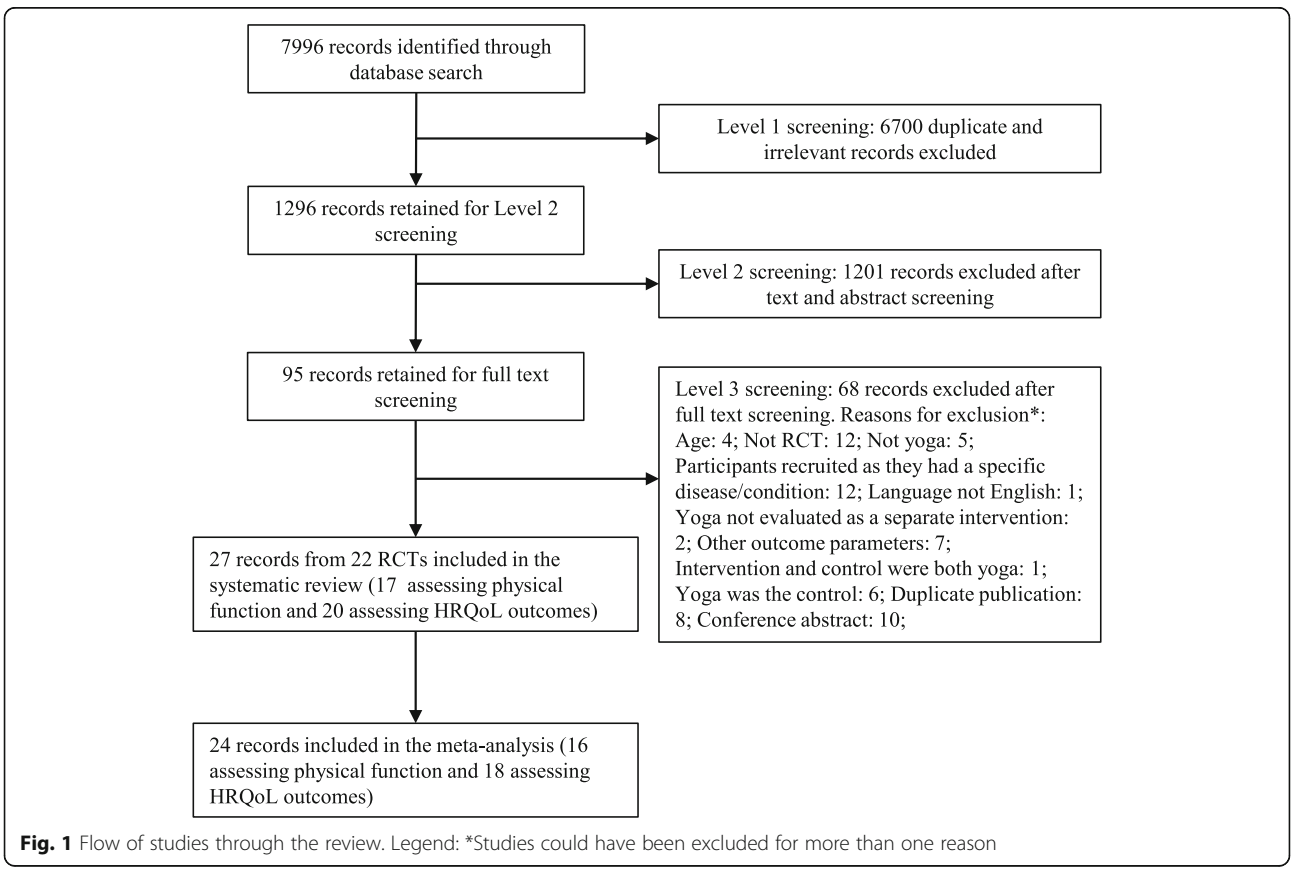


Fig. 1 Flow of studies through the review. Legend: *Studies could have been excluded for more than one reason

Table 2 Participant, intervention and study characteristics

Study id Country	Participants (number, mean age (SD))	Intervention group (type, frequency, session duration, length of intervention)	Control group(s)	Outcome measures
Bezerra (2014) [75] Brazil	*N* = 36 Mean age (SD): yoga group = 63.1 (13.3); control group = 61.0 (6.9) years.	Yoga, 3 times a week, 65 min per session, 12 weeks	1. IC: Control group	Physical function: Body weight
Bonura (2014) [63] USA	*N* = 98 Mean age (SD): 77.04 (7.28) years	Chair yoga, 1 session a week, 45 min per session, 24 weeks	1. AC: Chair exercise 2. IC: Wait-list control	HRQoL: Anger, anxiety, depression, well-being, general self-efficacy, self-efficacy for daily living, self-control
Bethany (2005) [55] USA	*N* = 42 Mean age (SD): 83.14 (4.84) years	Chair yoga, 3 times a week, 30 min per session, 6 weeks	1. AC: Chair aerobics 2. AC: Walking programme 3. IC: Game playing	HRQoL: Stress frequency, stress severity, state anxiety, depression, motivational factors to exercise
Chen (2008) [53] Taiwan	*N* = 176 Mean age (SD): Complete Silver Yoga = 65.81 (4.34); Shortened Silver Yoga = 68.08 (6.32); control group = 72.42 (6.04) years	1. Complete Silver Yoga with meditation, 3 times a week, 70 min per session, 24 weeks 2. Shortened Silver Yoga, 3 times a week, 55 min per session, 24 weeks	1. IC: Wait-list control	Physical function: Bodyweight, BMI, body fat percentage, lower body flexibility, upper limb strength, lower limb strength, balance, walking speed, range of motion: flexion and abduction of shoulder and hip joints on both sides
Chen (2009) [61] Taiwan	*N* = 128 Mean age (SD): 69.20 (6.23) years	Silver Yoga, 3 times a week, 70 min per session, 24 weeks	1. IC: Wait-list control	HRQoL: Sleep quality, depression, perceived mental and physical health
Chen (2010)1 [60] Taiwan	*N* = 55 Mean age (SD): 75.40 (6.70) years	Silver Yoga, 3 times a week, 70 min per session, 24 weeks	1. IC: Wait-list control	HRQoL: Sleep quality, depression, perceived mental and physical health
Chen (2010)2 [59] Taiwan	*N* = 55 Mean age (SD): 75.40 (6.70) years	Silver Yoga, 3 times a week, 70 min per session, 24 weeks	1. IC: Wait-listcontrol	Physical function: Body weight, BMI, body fat percentage, cardiopulmonary fitness, upper body flexibility, lower body flexibility and range of motion: flexion and abduction of shoulder and hip joints on both sides, upper limb and lower limb muscle strength, balance, and walking speed
Gothe (2016) [91] USA	*N* = 108 Mean age (SD): yoga group = 62.1 (5.82); control group = 62.0 (5.39) years	Hatha yoga, 3 times a week, 60 min per session, 8 weeks	1. AC: Stretching–strengthening control group	Physical function: Mobility, upper and lower limb strength, upper and lower body flexibility, balance, walking speed
Gothe (2013) [68] USA	*N* = 108 Mean age (SD): yoga group = 62.1 (5.82); control group = 62.0 (5.39) years	Hatha yoga, 3 times a week, 75 min per session, 8 weeks	1. AC: Stretching–strengthening control group	HRQoL: Stress, anxiety
Haber (1983) [70] USA	Centre1 N: 51 Mean age: 69 years Centre1 N: 35 Mean age: 70 years	The Easy Does it Yoga Programme for Older People, 1 session a week, Daily home practice encouraged, 10 weeks	1. IC: Control group (film series or art class)	HRQoL: Self assessed health status, psychological wellbeing

Table 2 Participant, intervention and study characteristics *(Continued)*

Study id Country	Participants (number, mean age (SD))	Intervention group (type, frequency, session duration, length of intervention)	Control group(s)	Outcome measures
Haber (1988) [66] USA	*N* = 410 Mean age: 75 years	The Easy Does it Yoga Programme for Older People, 3 times a week, 60 min per session, 10 weeks	1. IC: Control group	HRQoL: Self-care, sociability, medication usage
Hariprasad (2013) [74] India	*N* = 87 Mean age (SD): yoga group = 75.74 (6.46); control group = 74.78 (7.35) years	Yoga, daily supervised sessions for 1 month. 1 session per week in the 2nd and 3rd month. Daily home practice following this, 60 min per session, 24 weeks	1. IC: Wait-list control	HRQoL: Perceived physical and mental health, sleep
Krishnamurthy (2007) [92] India	*N* = 50 Mean age (SD): yoga group = 70.1 (8.3); ayurveda = 72.1 (9.0); wait-list = 72.3 (7.4) years	Yoga, 6 times a week, 60 min per session, 24 weeks	1. IC: Ayurveda group (herbal preparation) 2. IC: Wait-list control	Physical function: Balance, mobility
Krishnamurthy (2007)2 [58] India	*N* = 50 Mean age (SD): yoga group = 70.1 (8.3); ayurveda = 72.1 (9.0); wait-list = 72.3 (7.4) years	Yoga, 6 times a week, 60 min per session, 24 weeks	1. IC: Ayurveda group (herbal preparation) 2. IC: Wait-list control	HRQoL: Depression
Leininger (2006) [69] USA	*N* = 82 Mean age (SD): yoga group = 69.6 (6.7); education group = 68.2 (5.4) years	Hatha yoga, 2 supervised sessions a week. Home exercises recommended at least three times a week, 60 min per session, 10 weeks	1. IC: Education control group (on topics of osteoporosis and fitness)	Physical function: Balance, lower limb strength, HRQoL: Balance confidence, vitality
Manjunath (2005) [57] India	*N* = 50 Mean age (SD): yoga group = 70.1 (8.3); ayurveda = 72.1 (9.0); wait-list = 72.3 (7.4) years	Yoga training, 6 times a week, 60 min per session, 24 weeks	1. IC: Ayurveda (herbal preparation) 2. IC: Wait-list control	HRQoL: Sleep quality
Marques (2017) [78] Portugal	*N* = 25 Mean age (SD): 83.16 (7.4) years	Chair based yoga, 2 to 3 times a week, 50 min per session, 28 weeks	1. IC: Control group given education booklet	Physical function: Cardio-respiratory fitness, mobility, upper body flexibility HRQoL: Stress, perceived mental health
Morris (2008) [67] USA	*N* = 18 Mean age (SD): 76.06 (6.35) years	Hatha yoga, 2 times a week, 60 min per session, 8 weeks	1. AC: Balance training exercise 2. IC: Fall risk awareness	Physical function: Balance, fall frequency HRQoL: Fear of falls, balance confidence
Ni (2014) [56] USA	*N* = 39 Mean age (SD): 74.15 (6.99) years	Balance yoga programme, 2 times a week, 60 min per session, 12 weeks	1. AC: Tai Chi 2. AC: Standard balance programme	Physical function: Mobility, balance, walking speed
Nick (2016) [76] Iran	*N* = 39 Mean age (SD): yoga group = 68 (4.87); control group = 68.79 (4.81) years	Hatha yoga, 2 times per week, 60 min per session, 8 weeks	1. IC: Control group	Physical function: Balance HRQoL: Fear of falls
Noradechanunt (2017) [72] Australia	*N* = 33 Mean age (SD): 67.7 (6.7) years	Thai Yoga, 2 supervised session a week, 80 min per session. Home practice on alternate days for 20 min, 12 weeks	1. AC: Tai Chi 2. IC: Control group	Physical function: Lower and upper limb strength, lower and upper body flexibility, mobility HRQoL: Perceived physical and mental health, depression

Table 2 Participant, intervention and study characteristics *(Continued)*

Study id Country	Participants (number, mean age (SD))	Intervention group (type, frequency, session duration, length of intervention)	Control group(s)	Outcome measures
Oken (2006) [64] USA	*N* = 118 Mean age (SD): yoga group = 71.5 (4.9); exercise group = 73.6 (5.1); wait-list = 71.2 (4.4) years	Iyengar yoga, 1 class a week with home practice, 90 min per session, 24 weeks	1. AC: Walking group 2. IC: Wait-list control	Physical function: Lower body flexibility, lower limb strength, balance, walking speed HRQoL: Mood, fatigue, depression, perceived physical and mental health, pain, general health and well-being, social functioning, vitality
Saravanakumar (2014) [71] Australia	*N* = 33 Mean age (SD): 83.8 (7.9) years	Yoga, 2 times a week, 30 min per session, 14 weeks	1. AC: Tai Chi 2. IC: Usual care	Physical function: Balance, fall incidence, HRQoL: Pain, quality of life.
Tew (2017) [77] UK	*N* = 47 Mean age (SD): 74.8 (7.2) years	British Wheel of Yoga Gentle Years Yoga programme, 10 sessions during a 12-week period, 75 min. Home practice encouraged for 10–20 min on most days, 12 weeks	1. IC: Wait-list control	Physical function: Body weight, BMI, waist circumference, lower limb strength, upper and lower body flexibility, balance, walking speed HRQoL: Perceived mental health, quality of life
Tiedemann (2013) [73] Australia	*N* = 52 Mean age (SD): 68 years (7.1) years	Iyengar yoga, 2 session a week, 60 min. Home practice 2 days a week for 10–20 min, 12 weeks	1. IC: Control group given fall prevention education booklet	Physical function: Balance, lower limb strength, walking speed HRQoL: Fear of falls
Vogler (2011) [39] Australia	*N* = 38 Mean age (SD): 73.21 (8.38) years	Iyengar yoga, 2 times per week, 90 min per session. Home practice 3 days per week for 15–20 min, 8 weeks	1. IC: Wait-list control group	Physical function: Muscle strength, range of motion of the upper extremity, hip flexion, hip extension, hip abduction, and trunk rotation HRQoL: General health and well-being, perceived physical and mental health
Wang (2010) [65] USA	*N* = 18 Mean age (SD): 74.9 (8.4) years	Yoga group, 2 times per week, 60 min per session, 4 weeks	1. IC: Social group	Physical function: Balance, lower limb strength, lower body flexibility HRQoL: Depression, morale, hope, social isolation

HRQoL: health related quality of life; BMI: Body Mass Index; AC: Active control; IC: Inactive control; N: Number of participants analysed in included studies

Table 3 Types of yoga used in included studies

Types of yoga in included studies (number of studies, total number of participants)	Description
The types of yoga used in studies are similar in structure and postures, and their main features are highlighted below.	
Hatha yoga (4 studies, 247 participants)	Traditional yoga that includes combinations of postures, breathing, and meditation [93].
Chair yoga (3 studies, 165 participants)	This essentially follows a traditional Hatha yoga format, but is modified so that chairs are used during practice to accommodate physical limitations [63].
Iyengar yoga (3 studies, 208 participants)	Created by BKS Iyengar; based on Hatha yoga, but emphasis is on strength, balance, and use of props. Usually involves slow movement and holding poses [93].
Silver Yoga (2 studies, 231 participants)	The programme is based on Hatha yoga and Raja yoga (type of yoga that focuses on concentration and meditative techniques). The programme includes gentle stretching postures to increase range of motion and progressive muscle relaxation. Special consideration given for the physical abilities and tolerance of older adults [94].
Balance yoga programme (1 study, 39 participants)	This programme is based on a study by the authors showing specific muscle utilization patterns during different flow-based yoga poses. The programme has three levels of difficulty, becoming progressively challenging [56].
The Easy Does It Yoga Programme (2 studies, 496 participants)	Yoga programme designed for older adults [66].
Thai Yoga (1 study, 33 participants)	Thai Yoga is similar to the Hatha yoga style. However, it is less strenuous and incorporates postures that are less challenging and easier to perform than those of Hatha yoga [72].
British Wheel of Yoga (BWY) Gentle Years Yoga programme (1 study, 47 participants)	The British Wheel of Yoga (BWY) Gentle Years Yoga programme was developed to cater to the needs of older people with age-related conditions (osteoarthritis, hypertension, dementia, and sensory impairment). Hatha yoga poses were adapted so that older adults with comorbidities and physical limitations could safely participate [77].

position, Seated twists, Mountain pose, Warrior 1, Cobra, Chair pose, Eagle or Half eagle, Locust posture, Downward dog, Wind relieving pose, Child's pose, Standing hands on feet pose, Cow face pose, and Corpse pose (used for relaxation). The length of interventions ranged from four to 28 weeks, the most predominant being 24 weeks (6 studies) [53, 57, 59, 63, 64, 74] followed by 12 weeks (5 studies) [56, 72, 73, 75, 77], and eight weeks (4 studies) [39, 67, 68, 76]. The most common frequency of intervention was two sessions per week (9 studies) [39, 56, 65, 67, 69, 71–73, 76], followed by three sessions per week (6 studies) [53, 55, 59, 66, 68, 75]. Eight studies also encouraged practicing yoga at home in addition to class based sessions [39, 64, 69, 70, 72–74, 77]. Duration of classes ranged from 30 min to 90 min. A 60 min class duration was reported most frequently (9 studies) [56, 57, 65–67, 69, 73, 74, 76]. One study did not report class duration [70]. Inactive controls used in the studies were wait-list control (8 studies) [39, 53, 57, 59, 63, 64, 74, 77], playing games like Dominoes, Chinese Checkers and Scrabble [55], fall risk awareness [67], socialisation [65], education on osteoporosis and fitness [69], fall prevention education booklet [73], herbal preparation [57], telephone counselling [72], film series or art class [70], and usual care where no intervention was provided but participants could continue to use the facilities provided by the residential care centre like bingo, story-telling, exercise classes and gym [71]. Active controls included were Tai Chi (3 studies) [56, 71, 72], chair aerobics/exercise (2 studies) [55, 63], a walking programme (2 studies) [55, 64], balance training (2 studies) [56, 67], and stretching–strengthening exercises [68].

Results of vote counting

The vote-counting tables with all results for both physical function and HRQoL outcomes are presented in the supplementary section (Additional file 4).

Physical function

For yoga vs inactive controls, the "favouring yoga" category received most votes for the following outcomes (presented as: number of results where yoga had significantly positive effects compared with control / total number of results): cardio-respiratory fitness (2/3), flexibility (17/23, with lower body flexibility (5/7), ROM (10/13), upper body flexibility (2/3)), and walking speed (3/5). On no occasion did the inactive controls group receive more votes than yoga.

While comparing yoga and active controls, the "no significant difference" category got the highest number of votes for all outcomes.

HRQoL

For yoga vs inactive controls, the "favouring yoga" category received most votes for the following outcomes: quality of life (2/3), and sleep quality (3/4). In the yoga vs active controls analysis, the "favouring yoga" category did not receive the highest number of votes for any of the outcomes. The "favouring control" category received no votes for both yoga vs active and yoga vs inactive controls for any HRQoL outcomes.

Meta-analysis

Sixteen studies assessing physical function and 17 assessing HRQoL variables (from 18 records) were included in the meta-analysis (Table 4). Data used for meta-analysis are attached as supplementary tables (Additional file 5).

Physical function

Yoga vs inactive controls Yoga was found to significantly improve balance (ES (Hedges' g) = 0.7, 95% CI 0.19 to 1.22, $p = 0.01$), lower limb strength (ES = 0.45, 95% CI 0.22 to 0.68, $p < 0.001$), and lower body flexibility (ES = 0.50, 95% CI 0.30 to 0.69, $p < 0.001$) compared to inactive controls (Fig. 2). No significant difference between yoga and inactive controls was found for body composition (ES = 0.16, 95% CI -0.06 to 0.38, $p = 0.16$), upper body flexibility (ES = 0.28, 95% CI -0.02 to 0.58, $p = 0.07$) or walking speed (ES = 0.38, 95% CI -0.02 to 0.78, $p = 0.06$).

Yoga vs active controls There was a significant effect favouring yoga for lower limb strength (ES = 0.49, 95% CI 0.10 to 0.88, $p = 0.01$) and lower body flexibility (ES = 0.28, 95% CI 0.01 to 0.54, $p = 0.04$) (Fig. 3). No significant difference between yoga and active controls was found for balance (ES = 0.32, 95% CI -0.02 to 0.66, $p = 0.07$), mobility (ES = 0.31, 95% CI -0.25 to 0.87, $p = 0.28$) or walking speed (ES = – 0.29, 95% CI -0.79 to 0.22, $p = 0.26$).

HRQoL

Yoga vs. inactive controls There was a significant effect favouring yoga for depression (ES = 0.64, 95% CI 0.32 to 0.95, $p < 0.001$), perceived mental health (ES = 0.60, 95% CI 0.33 to 0.87, $p < 0.001$), perceived physical health (ES = 0.61, 95% CI 0.29 to 0.94, $p < 0.001$), sleep quality (ES = 0.65, 95% CI 0.41 to 0.88, $p < 0.001$), and vitality (ES = 0.31, 95% 0.03 CI to 0.59, $p = 0.03$) (Fig. 4). No significant effect was found for fear of falls (ES = 0.39, 95% CI

Table 4 Meta-analysis results- effect sizes and heterogeneity

Outcome	No. of studies	Total number of participants	Effect size		Heterogeneity	
			Hedges' g (95% CI)	*P*-value	I^2	*P*-value
Physical function - Yoga vs inactive controls						
Balance	7	265	**0.70 (0.19 to 1.22)**	**0.01**	72.15	0.001
Body composition	4	314	0.16 (–0.06 to 0.38)	0.16	0.00	0.91
Lower body flexibility	7	431	**0.50 (0.3 to 0.69)**	**< 0.001**	0.00	0.88
Lower limb strength	7	485	**0.45 (0.22 to 0.68)**	**< 0.001**	32.70	0.17
Upper body flexibility	4	166	0.28 (–0.02 to 0.58)	0.07	0.00	0.87
Walking speed	5	377	0.38 (–0.02 to 0.78)	0.06	72.69	0.003
Physical function - Yoga vs active controls						
Balance	5	264	0.32 (–0.02 to 0.66)	0.07	34.74	0.18
Lower body flexibility	3	225	**0.28 (0.01 to 0.54)**	**0.04**	0.00	0.59
Lower limb strength	3	225	**0.49 (0.1 to 0.88)**	**0.01**	47.44	0.15
Mobility	3	173	0.31 (–0.25 to 0.87)	0.28	58.73	0.06
Walking speed	3	192	–0.29 (– 0.79 to 0.22)	0.26	57.41	0.07
HRQoL - Yoga vs inactive controls						
Depression	8	450	**0.64 (0.32 to 0.95)**	**< 0.001**	57.09	0.02
Fear of falls	3	104	0.39 (–0.45 to 1.24)	0.36	75.64	0.02
Perceived mental health	9	554	**0.6 (0.33 to 0.87)**	**< 0.001**	54.87	0.02
Perceived physical health	5	400	**0.61 (0.29 to 0.94)**	**< 0.001**	58.55	0.05
Sleep quality	4	353	**0.65 (0.41 to 0.88)**	**< 0.001**	13.06	0.33
Social health	3	225	0.27 (–0.15 to 0.69)	0.2	51.76	0.13
Vitality	3	196	**0.31 (0.03 to 0.59)**	**0.03**	0.00	0.83
HRQoL - Yoga vs active controls						
Anxiety	3	206	0.43 (–0.03 to 0.88)	0.06	50.03	0.11
Depression	4	215	**0.54 (0.25 to 0.83)**	**< 0.001**	8.61	0.36
Perceived mental health	3	183	0.26 (–0.03 to 0.55)	0.08	0.00	0.81

CI: Confidence interval; Significant effect sizes (95% CI) and corresponding p values have been highlighted in bold

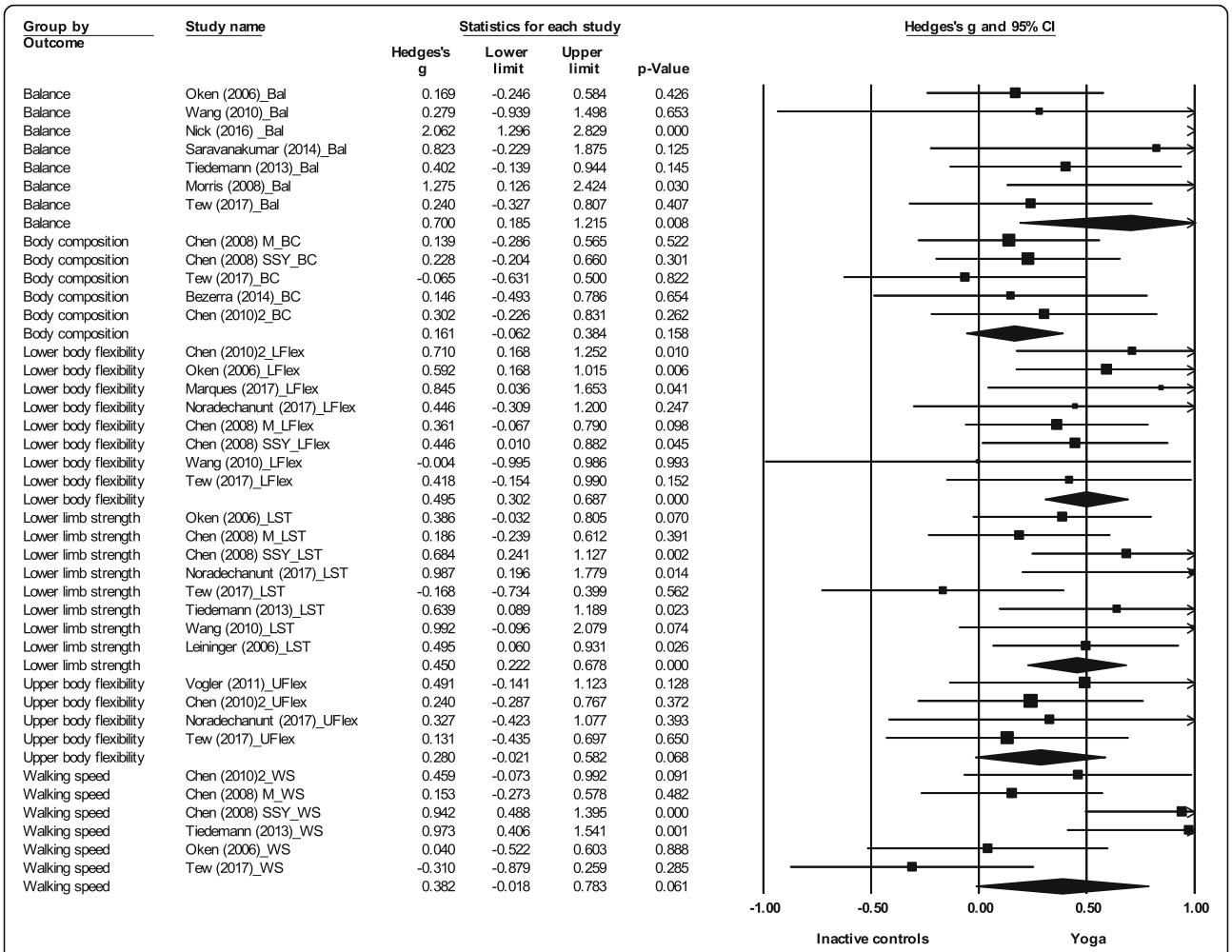


Fig. 2 Effect sizes and 95% confidence intervals for yoga compared to inactive controls on physical function outcomes. Legend: Bal: Balance; M: Yoga group with meditation; SSY: Short Silver Yoga; BC: Body composition; LFlex: Lower body flexibility; LST: Lower limb strength; UFlex: Upper body flexibility; WS: Walking speed

-0.45 to 1.24, $p = 0.36$) or social health (ES = 0.27, 95% CI -0.15 to 0.69, $p = 0.20$).

Yoga vs. active controls A significant effect favouring yoga was found for depression (ES = 0.54, 95% CI 0.25 to 0.83, $p < 0.001$) (Fig. 5). No significant effect was found for anxiety (ES = 0.43, 95% CI -0.03 to 0.88, $p = 0.06$) and perceived mental health (ES = 0.26, 95% CI -0.03 to 0.55, $p = 0.08$).

Heterogeneity

Statistically significant heterogeneity was found only when comparing yoga and inactive controls (Table 4). For physical function, significant substantial heterogeneity was found for balance ($I^2 = 72.15$, $p = 0.001$), and walking speed ($I^2 = 72.69$, $p = 0.003$). For HRQoL outcomes, statistically significant considerable heterogeneity was found for fear of falls ($I^2 = 75.64$, $p = 0.02$). Significant substantial heterogeneity was found for depression ($I^2 = 57.09$, $p = 0.02$), perceived mental health ($I^2 = 54.87$, p = 0.02), and perceived physical health ($I^2 = 58.55$, $p = 0.05$).

Combining data from different measurement instruments could introduce heterogeneity. For example, significant heterogeneity arose in the comparison of yoga and inactive controls when balance data from one-leg-stand test, Berg balance scale, standing balance tests and POMA were combined. In contrast, when lower body flexibility was measured using a single instrument (sit-and-reach/chair sit-and-reach test) no significant heterogeneity occurred.

Sensitivity analyses and cluster randomisation adjustment

Sensitivity analyses were conducted for four studies which had two controls, introducing one full control arm and then the other (Additional file 6). For one

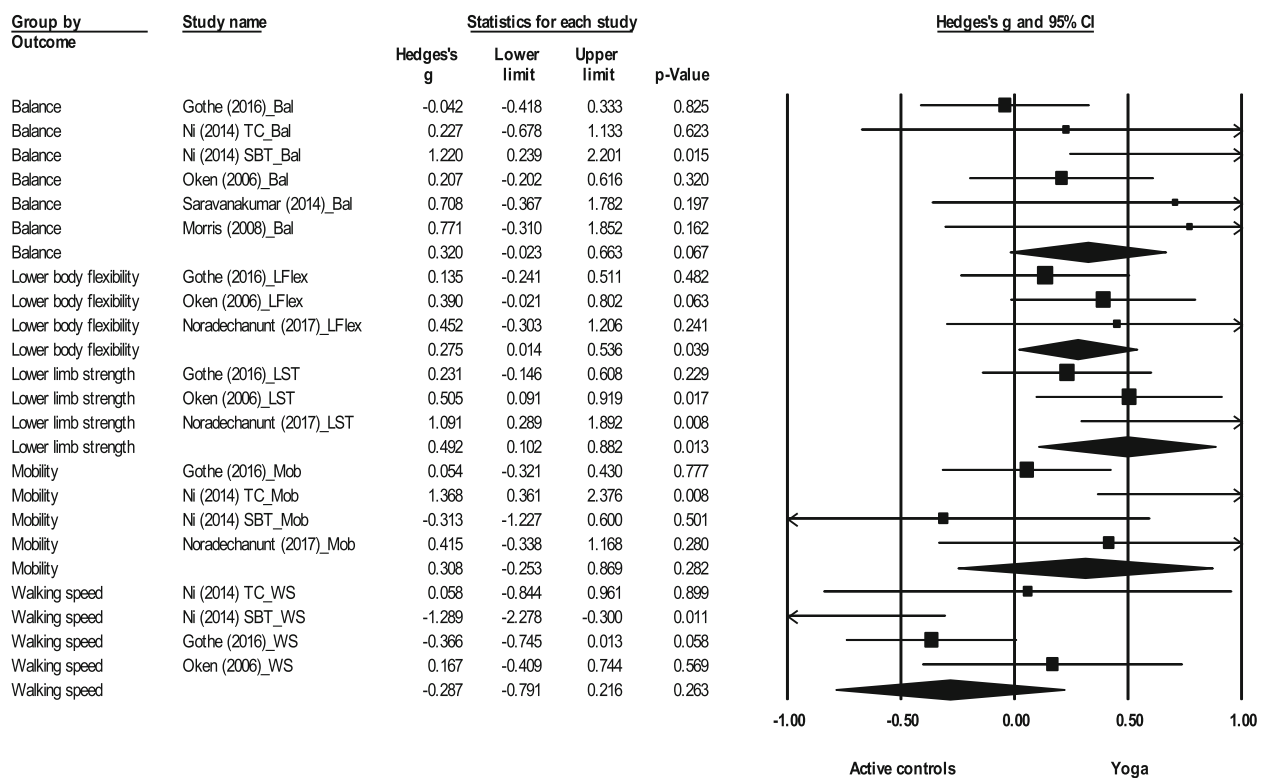


Fig. 3 Effect sizes and 95% confidence intervals for yoga compared to active controls on physical function outcomes. Legend: Bal: balance; TC: Tai Chi; SBT: Standard balance training; LFlex: Lower body flexibility; LST: Lower limb strength; Mob: Mobility; WS: Walking speed

study [56], yoga was compared with active controls, and the sensitivity analysis affected three outcomes (balance, mobility and walking speed). For the second study [55], yoga was compared to active controls affecting two HRQoL outcomes (anxiety and depression). The third [57] and fourth study [58] compared yoga with inactive controls and the sensitivity analysis affected sleep quality [57] and depression [58]. While there were small changes in effect sizes and *p* values, none of the variables crossed the significance thresholds, and conclusions derived from the original analysis were not altered.

Meta-analysis results were not greatly altered after taking into account cluster randomization (Additional file 7). While there was a small reduction in effect sizes for some outcomes, significance was not affected.

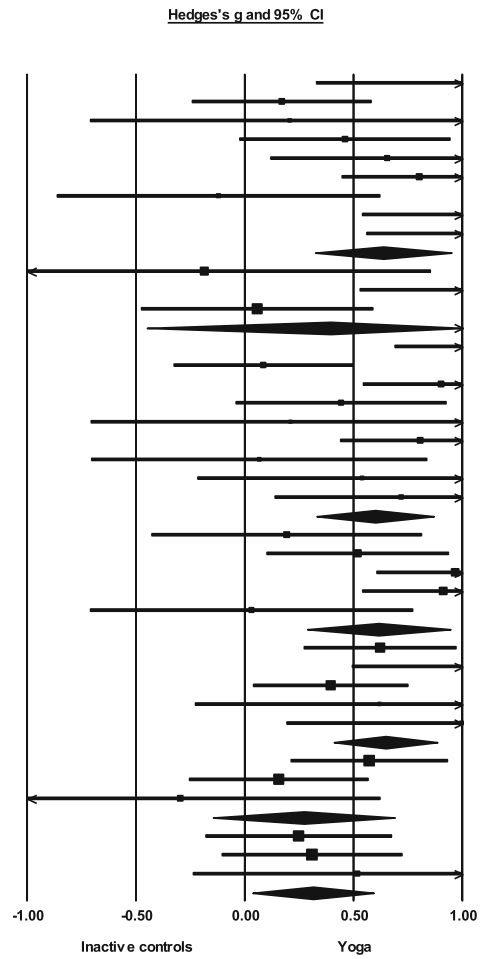
Risk of bias

For physical function, relatively few studies had high risk of bias (selection bias: random sequence generation (6%) and allocation concealment (18%), detection bias (6%), attrition bias (24%), reporting bias (18%) and other bias (41%)) (Fig. 6). Sample selection bias was evident for many studies and a small number were also at risk of contamination bias. Similarly, only few studies assessing HRQoL outcomes had high risk of bias (selection bias: random sequence generation (5%) and allocation concealment (10%), detection bias (10%), attrition bias (24%) and reporting bias (5%)) (Fig. 7). Other bias included response bias which emanates from the use of questionnaires and interviews, including social desirability response, acquiescence response and Hawthorne effect [48]. Since all studies assessing HRQoL used subjective self-report instruments, the risk of other bias is 100% for HRQoL outcomes. Detailed information on sources of bias is provided as supplementary material (Additional file 8).

Discussion

Summary of main findings

The results of this systematic review demonstrate that compared to inactive controls, it is possible for older adults to improve many aspects of their physical function and HRQoL through participating in a yoga intervention. Findings suggest that small to moderate sized beneficial effects can be achieved for balance, lower body flexibility, lower limb strength, depression, perceived mental health, perceived physical health, sleep quality, and vitality. When yoga was compared with active controls, statistically significant small to moderate effects favouring yoga were found for lower body strength, lower body flexibility and depression. Yoga



Group by Outcome	Study name	Hedges's g	Lower limit	Upper limit	p-Value
Depression	Bethany (2005)_Dep	1.228	0.326	2.130	0.008
Depression	Oken (2006)_Dep	0.171	-0.244	0.586	0.420
Depression	Wang (2010)_Dep	0.207	-0.713	1.126	0.659
Depression	Bonura (2014)_Dep	0.461	-0.026	0.948	0.064
Depression	Chen (2010)1_Dep	0.655	0.116	1.195	0.017
Depression	Chen (2009)_Dep	0.802	0.444	1.161	0.000
Depression	Noradechanunt (2017)_Dep	-0.120	-0.865	0.625	0.752
Depression	Krishnamurthy (2007)2 Ay_Dep	1.480	0.537	2.423	0.002
Depression	Krishnamurthy (2007)2 WL_Dep	1.403	0.557	2.248	0.001
Depression		0.635	0.322	0.948	0.000
Fear of falls	Morris (2008)_FOF	-0.185	-1.226	0.857	0.728
Fear of falls	Nick (2016)_FOF	1.197	0.527	1.867	0.000
Fear of falls	Tiedemann (2013)_FOF	0.058	-0.478	0.594	0.833
Fear of falls		0.393	-0.451	1.237	0.362
Per mental health	Vogler (2011)_PMH	1.383	0.687	2.079	0.000
Per mental health	Oken (2006)_PMH	0.085	-0.329	0.500	0.686
Per mental health	Chen (2009)_PMH	0.903	0.541	1.265	0.000
Per mental health	Bonura (2014)_PMH	0.443	-0.043	0.930	0.074
Per mental health	Wang (2010)_PMH	0.210	-0.709	1.130	0.654
Per mental health	Hariprasad (2013)_PMH	0.807	0.437	1.177	0.000
Per mental health	Marques (2017)_PMH	0.067	-0.707	0.841	0.865
Per mental health	Noradechanunt (2017)_PMH	0.539	-0.219	1.298	0.164
Per mental health	Tew (2017)_PMH	0.719	0.136	1.303	0.016
Per mental health		0.597	0.328	0.867	0.000
Per physical health	Vogler (2011)_PPH	0.193	-0.431	0.817	0.544
Per physical health	Oken (2006)_PPH	0.519	0.098	0.940	0.016
Per physical health	Chen (2009)_PPH	0.968	0.603	1.332	0.000
Per physical health	Hariprasad (2013)_PPH	0.912	0.538	1.286	0.000
Per physical health	Noradechanunt (2017)_PPH	0.032	-0.713	0.776	0.934
Per physical health		0.614	0.285	0.943	0.000
Sleep quality	Chen (2009)_Sleep	0.623	0.270	0.976	0.001
Sleep quality	Chen (2010)1_Sleep	1.052	0.491	1.612	0.000
Sleep quality	Hariprasad (2013)_Sleep	0.396	0.036	0.755	0.031
Sleep quality	Manjunath (2005) Ay_Sleep	0.620	-0.231	1.470	0.153
Sleep quality	Manjunath (2005) WL_Sleep	0.997	0.190	1.803	0.015
Sleep quality		0.645	0.408	0.883	0.000
Social health	Hariprasad (2013)_Soc	0.572	0.209	0.935	0.002
Social health	Oken (2006)_Soc	0.157	-0.258	0.572	0.458
Social health	Wang (2010)_Soc	-0.296	-1.218	0.626	0.530
Social health		0.270	-0.147	0.687	0.204
Vitality	Leininger (2006)_Vit	0.248	-0.182	0.679	0.258
Vitality	Oken (2006)_Vit	0.310	-0.107	0.726	0.145
Vitality	Noradechanunt (2017)_Vit	0.518	-0.240	1.276	0.180
Vitality		0.312	0.034	0.591	0.028

Fig. 4 Effect sizes and 95% confidence intervals for yoga compared to inactive controls on HRQoL outcomes. Legend: Dep: Depression; FOF: Fear of falls; Per mental health/PMH: Perceived mental health; Per physical health/PPH: Perceived physical health; Sleep: Sleep quality; Soc: Social health; Vit: Vitality; Ay: Ayurveda (herbal preparation); WL: Wait-list control

was found to be as good as the activity undertaken by active controls in improving outcomes such as mobility, walking speed, balance, anxiety and perceived mental health. The yoga group was never significantly worse than the active or inactive group for any of the outcomes. With high attendance rates for class-based sessions, yoga is a feasible intervention that can be recommended to older adults as an activity that improves physical and mental wellbeing.

Comparison to previous literature

While other systematic reviews have included or focused on studies that recruited older adults with clinical conditions, this review is the first to provide a comprehensive overview of the effects of yoga on physical function and HRQoL in an older adult population not characterised by a specific disease or condition. Outcomes such as depression, perceived mental and physical health, balance and mobility have been evaluated by other meta-analysis of RCTs in an older adult population (5), and are described in the section below.

Physical function

Youkhana et al. [10] conducted a systematic review to assess the effects of yoga on balance and mobility. Since the control groups in the review consisted of no intervention, waitlist control/usual care and provision of an education booklet, the study results can be contrasted with the inactive controls groups of the present study. Although the direction of the effect for balance is similar between the two reviews, the effect size in the inactive control group in this study is much higher than in the Youkhana et al. review (Table 5). The meta-analysis for balance in their review included six studies, with three studies in common with the inactive control group. The difference in effect size could be because of the extremely high effect size in one study included only in the

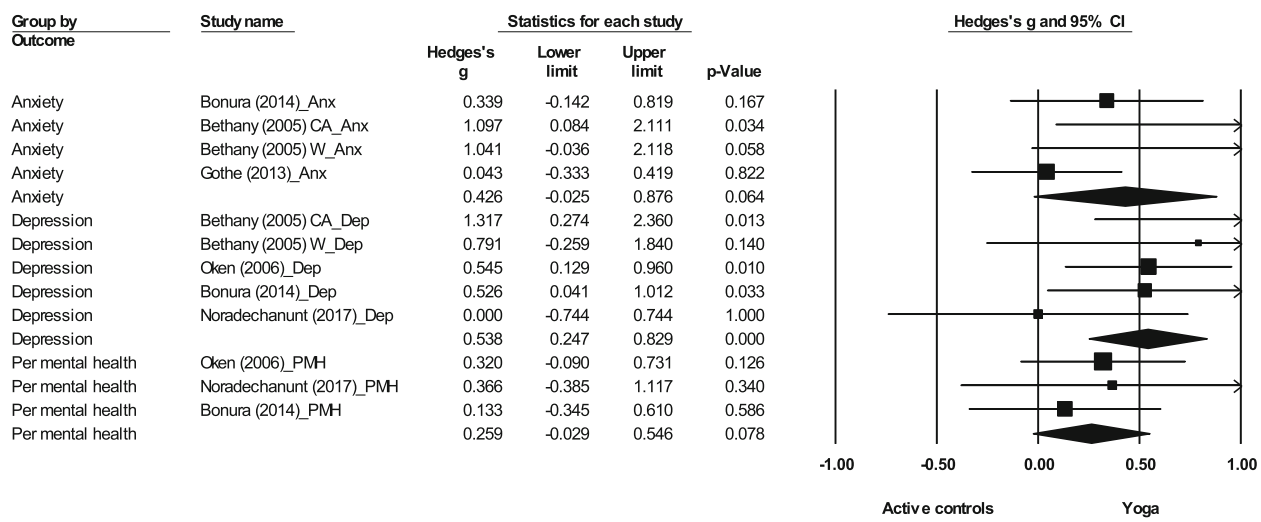


Fig. 5 Effect sizes and 95% confidence intervals for yoga compared to active controls on HRQoL outcomes. Legend: Anx: Anxiety; CA: Chair aerobics; W: Walking programme; Dep: Depression; Per mental health/PMH: Perceived mental health

current review, in which participants with poor balance were recruited, and saw great benefits from the yoga intervention [76]. Heterogeneity was lower and non-significant in their review for balance compared to the inactive control group in the current study. This could be attributed to more variation in the yoga types, as well as the inclusion of participants with poor balance at base-line in the current review.

The two reviews used different tests to assess mobility. Hence, a meta-analysis was conducted for mobility in the review by Youkhana et al. [10], but not in the current review while comparing yoga with inactive controls. The current study assessed mobility using the timed-up-and-go test (Additional file 9), which was measured only by two studies, and hence no meta-analysis was conducted. In the meta-analysis by Youkhana et al. [10], mobility was measured in three studies using the timed-eight-foot-walk, sit-to-stand test and the 4-m-walk. Two of the three studies [64, 73] were also included in the current review, with the sit-to-stand test included under strength and the 4-m-walk included under walking speed (Additional file 9).

HRQoL

Two reviews conducted meta-analyses to assess the effects of yoga on perceived mental and physical health in older adults [11, 13], and found a significant positive effect favouring yoga.

A smaller effect size was found for these outcomes in the Tulloch et al. review [13] compared to the current study (Table 5). The effect size in the present study for perceived physical and mental health in the inactive control group can be compared to HRQoL and mental wellbeing in the meta-analysis by Tulloch et al. correspondingly. The smaller effect size may be attributed to differences in inclusion criteria (studies which specifically recruited clinical populations were excluded in the current study), and only four of the 12 studies in the Tulloch et al. meta-analysis overlapped with the inactive control group of the present study. Some studies included in the current review [39, 65] were not captured by the Tulloch review due to differing search strategies, and search dates. The effect sizes for perceived physical and mental health in the meta-analysis by Patel et al. [11] were comparable to that of the inactive control group in the current study. Their review also assessed depression, and although a moderate effect size was found, it was not significant. The current meta-analysis for depression included more studies and may have the power to detect differences between groups. In line with the results of the current review, another systematic review published in Chinese [9] concluded that yoga significantly reduced depressive symptoms and improved quality of sleep in older adults.

Strengths and limitations

This systematic review and meta-analysis offers a comprehensive view of the effectiveness of yoga on both physical and psychological outcomes. The method of segregating controls into active and inactive groups has not been adopted by any other systematic review for this age group, and is a significant strength of this study. The review provides novel and valuable information on the effects of yoga on some salient outcomes like strength, vitality, and social health in an older adult population. No yoga RCT has directly assessed strength in older adults using techniques like isokinetic dynamometry (gold standard) or hand-held dynamometry [79]. To our knowledge this is the first study to conduct a

Study id	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective outcome reporting (reporting bias)	Other bias
Bezerra (2014)	Unclear	Unclear	Unclear	Unclear	Low	Unclear
Chen (2008)	Unclear	Unclear	Unclear	Low	High	High
Chen (2010)2	Unclear	High	Unclear	Low	High	High
Gothe (2016)	Unclear	Unclear	Unclear	Low	Low	Low
Krishnamurthy (2007)	Unclear	Unclear	Unclear	High	High	Unclear
Leininger (2006)	High	High	Low	Low	Low	High
Marques (2017)	Low	Low	Unclear	High	Low	Low
Morris (2008)	Unclear	Unclear	Unclear	High	Low	High
Ni (2014)	Unclear	Unclear	Unclear	High	Low	High
Nick (2016)	Low	High	High	Low	Low	Low
Noradechanunt (2017)	Low	Low	Low	Low	Low	Low
Oken (2006)	Low	Low	Low	Low	Low	Low
Saravanakumar (2014)	Low	Low	Low	Low	Low	Low
Tew (2017)	Low	Low	Low	Low	Low	High
Tiedemann (2013)	Low	Low	Low	Low	Low	Low
Vogler (2011)	Unclear	Unclear	Unclear	Low	Low	High
Wang (2010)	Unclear	Unclear	Unclear	Unclear	Low	Low

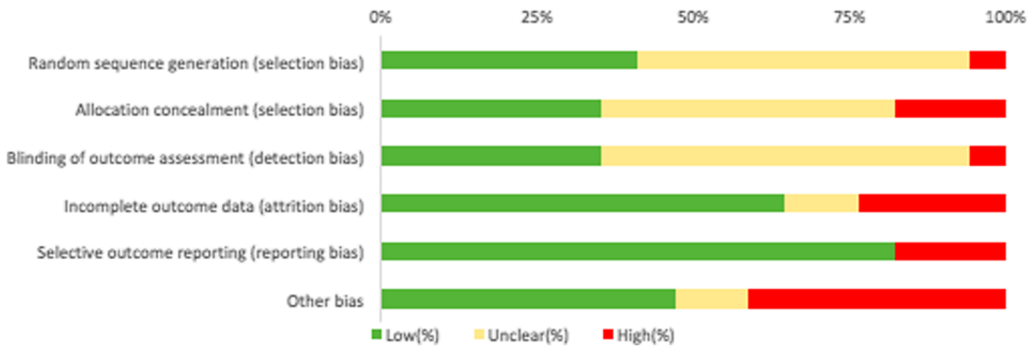


Fig. 6 Risk of bias table and graph for physical function outcomes

meta-analysis to comment on the effectiveness of yoga in improving strength albeit using a functional fitness measure as a proxy (sit-to-stand test). The sit-to-stand test is a reliable and valid indicator of lower body strength in older adults [80]. Used in conjunction with measures of flexibility, balance, mobility and walking speed, the sit-to-stand test is a fitting indicator of functional fitness and the ability to perform everyday activities in older adults [81].

This study had a broad search strategy, and criteria other than yoga and older adults were applied only at the screening stage, making it less likely to miss out studies. The review also included dissertations, which were not included in some previous reviews [11], leading to more robust results. However, the authors had difficulties in securing quantitative data for non-significant outcomes for some included studies (selective reporting bias) [53, 59], and these could not be incorporated in the meta-analysis. Consideration of this bias is critical since the primary studies test numerous outcomes, increasing the chance of type 2 errors. The inclusion of articles only published in English can be considered a limitation of the review. However, the review has captured studies from across the world including non-English speaking countries such as India, Taiwan, Brazil, and Iran. Only three studies [71, 73, 77] actually included adverse events as an outcome at the onset of the intervention. While eight studies reported on adverse events in the yoga group, it is not evident if there were no adverse events in the other studies, or if they were not reported. In one study [67] it is not clear if the injuries reported can be attributed to the yoga intervention. Ambiguous or no reporting of adverse events is a deficiency in yoga research, which future studies should address. While only a small proportion of included studies have been rated as high risk of bias, several studies have unclear risk of bias for random sequence generation, allocation concealment and blinding of outcome assessment. Future studies should ensure that

Study id	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective outcome reporting (reporting bias)	Other bias
Bethany (2005)	Unclear	Unclear	Unclear	Low	Low	High
Bonura (2014)	Unclear	Unclear	Unclear	Low	Low	High
Chen (2009)	Low	Unclear	Unclear	Low	Low	High
Chen (2010)1	Unclear	Unclear	Unclear	Low	Low	High
Gothe (2013)	Unclear	Unclear	Unclear	Low	Low	High
Haber (1983)	Unclear	Unclear	Unclear	High	Unclear	High
Haber (1988)	Unclear	Unclear	Unclear	Unclear	Low	High
Hariprasad (2013)	Unclear	Low	Unclear	Low	Low	High
Krishnamurthy (2007)2	Low	Low	Unclear	High	Low	High
Leininger (2006)	High	High	Low	Low	Low	High
Manjunath (2005)	Low	Low	Low	High	Low	High
Marques (2017)	Low	Low	Unclear	High	Low	High
Morris (2008)	Unclear	Unclear	Unclear	High	Low	High
Nick (2016)	Low	High	High	Low	Low	High
Noradechanunt (2017)	Low	Low	Low	Low	Low	High
Oken (2006)	Low	Low	Low	Low	High	High
Saravanakumar (2014)	Low	Low	High	Low	Low	High
Tew (2017)	Low	Low	Low	Low	Low	High
Tiedemann (2013)	Low	Low	Low	Low	Low	High
Vogler (2011)	Unclear	Unclear	Unclear	Low	Low	High
Wang (2010)	Unclear	Unclear	Unclear	Unclear	Low	High

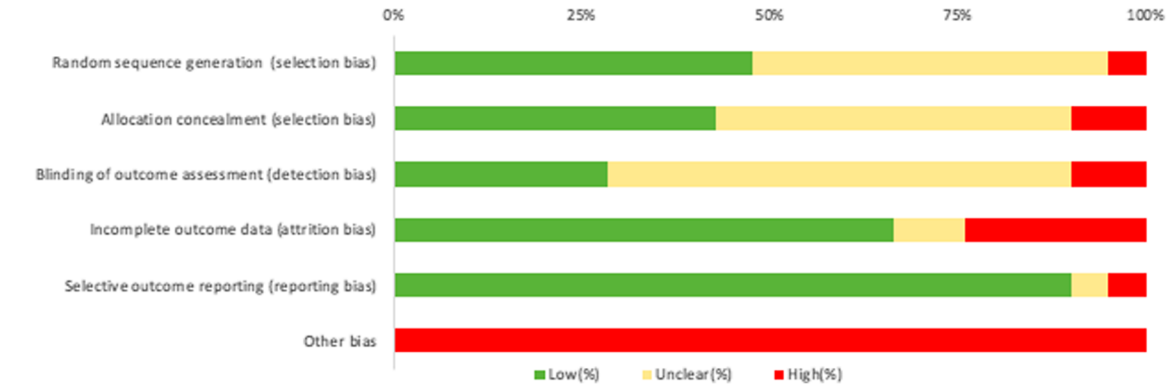


Fig. 7 Risk of bias table and graph for HRQoL outcomes

randomisation and data collection procedures are reported in detail to allow for accurate assessment of bias and reliability of intervention effects.

The classification of test and instruments into broad physical function and HRQoL categories was carried out in a structured manner, referring to literature when available, to support the decisions made. However, this process can be subjective, and could be the root of differences in effect sizes between reviews (for example, sit-to-stand test was classified as assessing mobility in the Youkhana et al. review [10], but was categorised as evaluating lower limb strength in the present review).

Implications for policy and practice

The study offers clear evidence that compared to no activity, yoga improves physical function and psychological wellbeing in older adults. It can be inferred from the meta-analysis results that yoga improves muscle strength and balance. Previous systematic reviews have highlighted the potential of yoga in improving balance in healthy adults [82], and PA policy should continue to promote yoga within muscle strength and balance guidelines to enhance and maintain health. Approximately 15% of older adults are likely to suffer from a mental health disorder [83], with depression affecting 22% of older men and 28% of older women in the UK [84]. Mental wellbeing is critical for an older adult population, and this review highlights the beneficial effects of yoga in improving perceived physical and mental health, vitality, and alleviating depressive symptoms.

The findings from this review could be used to challenge older adults' perceptions of yoga. Older adults have the impression that yoga only improves flexibility, and the lack of an aerobic component has been cited as

Table 5 Comparison of effect sizes from previous reviews and the current review

Outcome	Study	Effect size in comparator review	Effect size present review	Notes
Balance	Youkhana et al. (2016)	Hedges' g = 0.40, 95% CI 0.15 to 0.65. $I^2 = 0.00\%$, $p = 0.615$	Inactive controls: Hedges' g = 0.70, 95% CI 0.19 to 1.22. $I^2 = 72.15$, $p = 0.001$	Larger effect size in current review may be attributed to inclusion of a RCT [76] which recruited participants with poor balance at baseline.
Mobility	Youkhana et al. (2016)	Hedges' g = 0.50, 95% CI 0.06 to 0.95. $I^2 = 51.8\%$, $p = 0.126$	Inactive controls: No meta-analysis for mobility	Mobility assessed by timed-up-and-go test in the current review (measured by only 2 studies). Mobility measured in Youkhana et al. (2016) by three studies using the timed-eight-foot-walk, sit-to-stand test and the 4-m-walk.
Perceived mental health	Tulloch et al. (2018)	Hedges' g = 0.38, 95% CI 0.15 to 0.62. $I^2 = 56.3\%$, $p = 0.009$	Inactive controls: Hedges' g = 0.6, 95% CI 0.33 to 0.87. $I^2 = 54.87$, $p = 0.02$	Larger effect size in current review may be attributed to differences in inclusion criteria, differing search strategies, and search dates.
	Patel et al. (2012)	SMD = 0.66, 95% CI 0.10 to 1.22. $I^2 = 77\%$		Comparable effect size.
Perceived physical health	Tulloch et al. (2018)	Hedges' g = 0.51, 95% CI 0.25 to 0.76. $I^2 = 62.9\%$, $p = 0.002$	Inactive controls: Hedges' g = 0.61, 95% CI 0.29 to 0.94. $I^2 = 58.55$, $p = 0.05$	Larger effect size in current study may be attributed to differences in inclusion criteria, differing search strategies, and search dates.
	Patel et al. (2012)	SMD = 0.65, 95% CI 0.02 to 1.28. $I^2 = 82\%$		Comparable effect size.
Depression	Patel et al. (2012)	SMD = − 0.57, 95% CI - 1.17 to 0.04. $I^2 = 80\%$ (The negative effect size here indicates that yoga reduces depression scores to a greater extent than comparison groups)	Inactive controls: Hedges' g = .64, 95% CI 0.32 to 0.95. $I^2 = 57.09$, $p = 0.02$	Inclusion of more RCTs may have increased the power to detect differences between groups, producing significant effects favouring the yoga group in the current study.

SMD: Standardised Mean Difference, *CI*: Confidence Interval, *RCT*: Randomised Controlled Trial

a barrier to yoga participation [85]. The older population and yoga teachers need to be educated on the muscle strength and balance guidelines, and also made aware of the physical function and HRQoL benefits of yoga as evidenced by this study. Information from the studies included in this review (e.g. common yoga postures and class structure) should be shared with yoga teachers. Although not directly examined in relation to effectiveness, the cross tabulation of frequency and duration of class-based sessions (Additional file 10) showed that 60 min on two days a week was the most common, which can be easily translated to practice.

Yoga is a recognised and accepted form of activity in India where it originated. In western countries, although an increasing trend in older adult participation in yoga/pilates has been observed [86–88], yoga participation rates still remain low [87, 89, 90]. This review adds to the growing evidence on the benefits of yoga, and researchers should work closely with yoga teachers, studios, fitness centres and policy makers to develop and implement strategies to encourage yoga participation among older adults, tying in with the final aim of increasing participation in muscle strength and balance activities.

Future research

Future intervention studies should include an active control arm, so that conclusions can be drawn with respect to the effectiveness of yoga compared to different exercise programmes. Upper limb strength, hand grip strength, fall frequency, balance confidence, stress and self-efficacy are relevant and important outcomes for this population. The effects of yoga on these outcomes could not be computed through a meta-analysis due to lack of studies, and future research with robust experimental designs should focus on these outcomes. Future systematic reviews for the older adult population should aim to comment on dose-response relationships. The current review assessed the effects of yoga immediately after the intervention, and 28-weeks was the longest follow-up period. Future reviews should assess effects over a longer period, taking into account post-intervention follow-up data. Moreover, this review did not include physiological (e.g. cholesterol, indicators of immune function) and cognitive outcomes (e.g. memory and executive functions) and future reviews could aim to assess these outcomes.

There is a need to develop an appropriate framework for assessing physical function in an older adult population. Health Related Physical Fitness is defined in the American College of Sports Medicine manual as consisting of those specific components of physical fitness that have a relationship with good health, and includes cardio-respiratory fitness, body composition, muscular strength and flexibility [16]. However, it does not include mobility, walking speed, balance and frequency of falls which are important parameters of health for this population. Moreover, clear guidance is needed on the tests and instruments that assess these aspects, with details on whether they are a valid measure of the outcomes assessed. A study may have more than one instrument assessing the same outcome, and there is no standard procedure for choosing which one measure to include in the meta-analysis. This is a potential source of bias, and guidance for this process should be developed to reduce subjectivity.

Conclusion

Results of this systematic review and meta-analysis show that yoga improves multiple physical function and HRQoL outcomes in older adults not characterised by any specific disease or condition. Compared to inactive controls, small to moderate significant effects favouring yoga were found for balance, lower body flexibility, lower limb strength, depression, perceived mental health, perceived physical health, sleep quality, and vitality. When yoga was compared with active controls, significant small to moderate effects were also found for lower body strength, lower body flexibility and depression. Yoga is a multimodal activity that improves muscle strength, balance and flexibility in older adults, and physical activity policy should continue to promote yoga as an activity that enhances physical and mental wellbeing in this population.

Additional files

Additional file 1: Search terms for Ovid databases (MEDLINE, PsycInfo, EMBASE, AMED). Detailed list of search terms used for OVID databases are provided in this file. (PDF 37 kb)

Additional file 2: Data extraction template. This is the custom data extraction template used in the study. (XLSX 12 kb)

Additional file 3: The formula used in the study for calculating the sample size after adjusting for cluster randomisation is provided in this file. The studies included in this analysis are also listed in this document. (PDF 1175 kb)

Additional file 4: Vote count tables for physical function and HRQoL outcomes. The tables contain columns for outcome, study name, tests and instrument used, intervention and controls, and whether there were significant effects. (PDF 412 kb)

Additional file 5: (i) Data for meta-analysis- yoga compared with inactive controls for physical function outcomes. (ii) Data for meta-analysis- yoga compared with active controls for physical function outcomes. (iii) Data for meta-analysis- yoga compared with inactive controls for HRQoL outcomes. (iv) Data for meta-analysis- yoga compared with active controls for HRQoL outcomes. This excel file has four tabs which contain the data used in the main meta-analyses analyses (physical function and HRQoL outcomes for yoga vs inactive controls and yoga vs active controls) presented in this review. (XLSX 29 kb)

Additional file 6: Sensitivity analysis results. Results of the sensitivity analysis conducted are provided in this document. This includes Forest plots and homogeneity data. (PDF 307 kb)

Additional file 7: Cluster randomisation adjustment results- Forest plots and homogeneity data. Results of the cluster randomisation adjustment analysis are provided in this document. This includes Forest plots and homogeneity data. (PDF 29 kb)

Additional file 8: (i) Risk of bias details for physical function outcomes. (ii) Risk of bias details for HRQoL outcomes. This excel file has two tabs with the risk of bias details for physical function and HRQoL outcomes. (XLSX 25 kb)

Additional file 9: This table consists of the tests/instrument used to measure each outcome for all studies included in the meta-analysis (XLSX 13 kb)

Additional file 10: Frequency and duration of yoga sessions from studies included in the systematic review. This is a cross-tab of frequency and duration of yoga interventions from studies included in the meta-analysis. (XLSX 9 kb)

Abbreviations
BMI: Body Mass Index; CI: Confidence Interval; ES: Effect Size; HRQoL: health related quality of life; MS: Muscle Strength; PA: Physical Activity; POMA: Performance Oriented Mobility Assessment; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses; RCT: Randomised Controlled Trials; ROM: Range of Motion; SMD: Standardised Mean Difference; UK: United Kingdom; US: United States

Acknowledgements
Authors would like to thank Marshal Dozier who helped with database searching, and Dr. Anne Martin for her inputs on methodology and analysis.

Funding
DiS is funded by a College PhD Scholarship (University of Edinburgh).

Availability of data and materials
Data and results for the main meta-analyses presented in this study are included in this published article (and its supplementary information files). Results for sensitivity analysis and cluster randomisation adjustment analysis are included as supplementary files. The datasets for these analyses are available from the corresponding author on request.

Authors' contributions
DiS, CF, GB, NM conceived the study. DiS, CF, GB, NM established eligibility criteria. DiS, KL, GB, CF worked on study selection, data extraction and quality assessment. DiS, CF, GB, PK and DaS contributed to analysis. PK and DaS provided input and support at all stages of the project. DiS drafted the manuscript. All authors contributed to manuscript development and read and approved the final draft.

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

Publisher's Note

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Received: 25 July 2018 Accepted: 8 March 2019
Published online: 05 April 2019

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Appendix 3. Search terms for Ovid databases (MEDLINE, PsycInfo, EMBASE, AMED)

This file can be accessed here- https://static-content.springer.com/esm/art%3A10.1186%2Fs12966-019-0789-2/MediaObjects/12966_2019_789_MOESM1_ESM.pdf

Appendix 4. Data extraction template

This file can be accessed here- https://ijbnpa.biomedcentral.com/articles/10.1186/s12966-019-0789-2 (under Additional file 2)

Appendix 5. Formula for calculation of sample size after adjusting for cluster randomisation

This file can be accessed here- https://static-content.springer.com/esm/art%3A10.1186%2Fs12966-019-0789-2/MediaObjects/12966_2019_789_MOESM3_ESM.pdf

Appendix 6. Vote count tables for physical function and HRQoL outcomes

This file can be accessed here- https://static-content.springer.com/esm/art%3A10.1186%2Fs12966-019-0789-2/MediaObjects/12966_2019_789_MOESM4_ESM.pdf

Appendix 7. Excel file with data used in main meta-analyses

This file can be accessed here- https://ijbnpa.biomedcentral.com/articles/10.1186/s12966-019-0789-2 (under Additional file 5)

Appendix 8. Sensitivity analysis results

This file can be accessed here- https://static-content.springer.com/esm/art%3A10.1186%2Fs12966-019-0789-2/MediaObjects/12966_2019_789_MOESM6_ESM.pdf

Appendix 9. Cluster randomisation adjustment results- Forest plots and homogeneity data

This file can be accessed here- https://static-content.springer.com/esm/art%3A10.1186%2Fs12966-019-0789-2/MediaObjects/12966_2019_789_MOESM7_ESM.pdf

Appendix 10. Excel file with Risk of bias details

This file can be accessed here- https://ijbnpa.biomedcentral.com/articles/10.1186/s12966-019-0789-2#Bib1 (under Additional file 8)

Appendix 11. Tests and instruments used by studies to measure each outcome in the meta-analysis

This file can be accessed here- https://ijbnpa.biomedcentral.com/articles/10.1186/s12966-019-0789-2#Bib1 (under Additional file 9)

Appendix 12. Frequency and duration of yoga sessions from studies included in the systematic review

This file can be accessed here- https://ijbnpa.biomedcentral.com/articles/10.1186/s12966-019-0789-2#Bib1 (under Additional file 10)

Appendix 13. Mapping tests and instruments to broad physical function outcomes

1. Cardio-respiratory fitness

#	Test/instrument/Parameter	Reference used to classify
1	VO2 peak/ VO2max	1. Health Related Physical fitness framework (Kaminsky, 2010)
2	The 2-minute step test	1. Rikli and Jones (1999)
3	6-min walk test	1. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories (2002)

2. Muscular strength and endurance

#	Test/instrument/ Parameter	What does it measure?	Reference used to classify
1	Hand-grip strength	Muscle strength	1. Health Related Physical fitness framework (Kaminsky, 2010) 2. Shirley Ryan AbilityLab (2014)
2	Chair-stand test/ sit-to-stand test	Lower limb strength and endurance	1. Rikli and Jones (1999) 2. Middleton and Fritz (2013) 3. Bohannon, Bubela, Magasi, Wang, & Gershon (2010)
3	The Arm Curl test	Upper limb muscle endurance	1. Dunsky, Ayalon, and Netz (2011)
4	Timed Floor Transfer (TFT)	Lower limb strength	1. Murphy, Olson, Protas, and Overby (2003)
5	Manual muscle testing	Muscle strength	1. Shirley Ryan AbilityLab (2013b) 2. Hislop, Avers, & Brown (2013)

3. Flexibility

#	Test/instrument/Parameter	What does it measure?	Reference used to classify
1	Chair sit-and-reach test/ Sit-and-reach test	Lower body flexibility	1. Mayorga-Vega, Merino-Marban, and Viciana (2014)
2	Range of motion (measured using Goniometer)	Flexibility	1. Health Related Physical fitness framework (Kaminsky, 2010)
3	Back-scratch test	Upper body flexibility	1. Rikli and Jones (1999)

4. Mobility and walking/gait speed

#	Test/instrument/Parameter	What does it measure?	Reference used to classify
1	8-foot up-and-go test/ Timed up and go (TUG) test	Mobility	1. Rikli and Jones (1999) 2. Middleton and Fritz (2013) 3. Shirley Ryan AbilityLab (2013c)
2	Stairs up/stairs down	Mobility	1. Zaino, Marchese, and Westcott (2004)
3	6-m walk test (interpreted as 6-meter walk test. Study protocol: the subjects were asked to walk in a straight path as fast as they could, reach a predetermined object, turn and then come back to the start. The time spent to complete the task was recorded in seconds)	Gait speed	1. Lam, Lau, Chan, & Sykes (2010) 2. Middleton and Fritz (2013)
4	Maximal walking speed/ Usual walking speed	Walking speed	1. Middleton, Fritz, and Lusardi (2015)
5	Short Physical Performance Battery 4-meter walk/ timed 4-m walk at fast pace	Gait speed	1. Middleton and Fritz (2013)

5. Balance

#	Test/instrument/Parameter	What does it measure?	Reference used to classify
1	One-leg-stand test	Static Balance	1. Springer, Marin, Cyhan, Roberts, & Gill (2007) 2. Prost (2018)
2	Berg Balance Scale (BBS)	Functional balance	1. Middleton and Fritz (2013)
3	Standing balance tests (consisting of standing balance component of the short physical performance battery, with the addition of one-legged stance time)	Static + Dynamic Balance tests	1. Guralnik et al. (1994) 2. Prost (2018)
4	Tinetti balance and gait evaluation test/ Performance Oriented Mobility Assessment (POMA)	balance and gait (Separate measures)	1. Bushnik (2011) 2. Middleton and Fritz (2013)
5	Four Square Step TesT	Dynamic Balance	1. Shirley Ryan AbilityLab (2013a) 2. Prost (2018)
6	Functional reach (FR)	Functional balance	1. Middleton and Fritz (2013)

7	Dynamic posturography test	Balance and postural control	1. Hall & Herdman (2005)
8	NeuroCom Pro Balance Master test	Balance	1. (Natus Balance & Mobility) Note: protocol used in the study (Morris, 2008) similar to the protocol Limits of Stability test listed in the page
9	Postural sway	Balance/postural control	1. Pavol (2005)
10	Maximum excursion (MXE) measured by Limits of Stability (LOS)	Balance	1. (Natus Balance & Mobility)
11	COG Sway Velocity via Unilateral stance (US) test	Dynamic balance	1. (Natus Balance & Mobility)

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Appendix 14. Mapping tests and instruments to broad health related quality of life outcomes

1. Anxiety

#	Test/instrument/Parameter	Reference used to classify
1	State-Trait Anxiety Inventory- state scores	1. Julian (2011)
2	State-Trait Anxiety Inventory- trait scores	

2. Depression

#	Test/instrument/Parameter	Reference used to classify
1	Beck Depression Inventory - II	1. Jackson-Koku (2016)
2	Epidemiologic Studies Depression Scale (CESD-10).	1. (Shirley Ryan AbilityLab)
3	Geriatric Depression Scale	1. Shirley Ryan AbilityLab (2013)
4	Hamilton Depression Rating scale	1. Sharp (2015)
5	Taiwanese Depression Questionnaire	1. Lee et al. (2008)

3. Perceived physical health

#	Test/instrument/Parameter	Reference used to classify
1	Physical Well-Being subscale of the Life's Odyssey Questionnaire	Unable to find information on this instrument. Removed from analysis
2	Physical Component Summary of the SF-12v2/Physical health component SF-12 Healthy Survey, Chinese version	1. Jenkinson et al. (1997)
3	Physical Health Composite Summary score of the Short Form-36	1. Lins & Carvalho (2016)
4	WHOQOL-BREF- Physical health domain	1. Shirley Ryan AbilityLab (2014)

4. Perceived Mental health

#	Test/instrument/Parameter	Reference used to classify
1	Life's Odyssey Questionnaire (three subscales of the Life's Odyssey Questionnaire - Life, Health and Attitude; Emotional Well-Being; and Self-Care).	Unable to find information on this instrument. Removed from analysis
2	Mental Component Summary of the SF-12v2/ Mental health component of SF-12 Healthy Survey, Chinese version	1. Jenkinson et al. (1997)
3	Mental Health Composite Summary score of the Short Form-36	1. Lins & Carvalho (2016)
4	Lawton's PGC Morale Scale/Philadelphia Geriatric Center Morale Scale- Revised (PGMS)	1. Lawton (2003)
5	WHOQOL-BREF- mental health domain	1. Shirley Ryan AbilityLab (2014)
6	WHO-5	1. Topp, Østergaard, Søndergaard, & Bech (2015)
7	Warwick- Edinburgh Mental Well-being Scale (WEMWBS)	1. Taggart et al. (2013)

5. General Health and Well-Being

#	Test/instrument/Parameter	Reference used to classify
1	Subscale from SF-12v2	1. Jenkinson et al. (1997)
2	Subscale from Short Form-36	1. Lins & Carvalho (2016)

6. Vitality

#	Test/instrument/Parameter	Reference used to classify
1	Subscale from SF-36	1. Lins & Carvalho (2016)

7. Quality of life

#	Test/instrument/Parameter	Reference used to classify
1	dementia quality of life (DQOL) questionnaire	1. Brod, Stewart, Sands, & Walton (1999) 2. Moyle, Gracia, Murfield, Griffiths, & Venturato (2012)
2	WHOQOL-OLD	1. Power, Quinn, & Schmidt (2005)
3	EQ-5D utility index	1. https://euroqol.org/eq-5d-instruments/ (EuroQol)
4	EQ-VAS	1. https://euroqol.org/eq-5d-instruments/ (EuroQol)

8. Social health

#	Test/instrument/Parameter	Reference used to classify
1	two of the Life's Odyssey subscales: Social Connectedness; and Rest, Pleasure, and Play.	Unable to find information on this instrument. Removed from analysis
2	WHOQOL-BREF- social relationships domain	1. Shirley Ryan AbilityLab (2014)
3	Social functioning from the Short Form-36	1. Lins & Carvalho (2016)
4	UCLA Loneliness Scale (social isolation)	1. Russell, Peplau, & Cutrona (1980)
5	self-reported frequency of conversation and perceived closeness to others in the nursing home (sociability)	1. Haber (1988)
6	Social participation from WHOQOL-OLD	1. Power, Quinn, & Schmidt (2005)

9. Sleep quality

#	Test/instrument/Parameter	Reference used to classify
1	Pittsburgh Sleep Quality Index (PSQI) PSQI total score	1. Bysse, Reynolds III, & Monk (1989)
2	Sleep rating questionnaire: 5 questions	1. Manjunath & Telles (2005)

10. Fear of falls

#	Test/instrument/Parameter	Reference used to classify
1	Fear Efficacy Scale (self-efficacy)	1. Tinetti, Richman, & Powell (1990)
2	Modified Falls Efficacy Scale (MFES)	1. Hill, Schwarz, Kalogeropoulos, & Gibson (1996)
3	Short Falls Efficacy Scale-International (Short FES-I)	1. Kempen et al. (2007)

11. Stress

#	Test/instrument/Parameter	Reference used to classify
1	Perceived Stress Scale 14-item Perceived Stress Scale	1. Cohen, Kamarck, & Mermelstein (1994)
2	Salivary Cortisol (pre and post stressor)	1. Bozovic, Racic, & Ivkovic (2013)
3	Hassles Scale (Stress Frequency)	1. Kanner, Coyne, Schaefer, & Lazarus (1981)
4	Hassles Scale (Stress Severity)	1. Kanner, Coyne, Schaefer, & Lazarus (1981)

12. Balance confidence

#	Test/instrument/Parameter	Reference used to classify
1	Activities- Specific Balance Confidence (ABC) Scale	Myers, Fletcher, Myers, & Sherk (1998)

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Annals of Yoga and Physical Therapy

Open Access

Austin Publishing Group

Research Article

Perceptions of Yoga among Older Adults: A Qualitative Approach

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Received: August 08, 2017; **Accepted:** October 25, 2017; **Published:** November 01, 2017

Abstract

A very low percentage of older adults in Scotland meet the muscle strengthening, balance and co-ordination guidelines. Practicing yoga has benefits for older adults including improved strength, flexibility, mobility and balance. To develop an appropriate yoga programme for older adults, it is important to get an in-depth understanding of their perceptions of yoga. We conducted focus group discussions and interviews with a total of 19 male and female older adult participants, both with and without prior yoga experience. Thematic and framework analysis were used to analyze the transcripts, and explore the differences in perceptions between the yoga and non-yoga participants. The study offers insights into how older adults perceive yoga including knowledge of yoga, thoughts on the features and perceived intensity of yoga practice, the gendered nature of participation, benefits, and apprehensions. Guidelines for instructors while working with older adults include being audible, giving clear instructions and demonstrating in class. Creating a non-threatening environment, being aware of the level of the class, and offering alternative postures are other suggestions to aid the effective delivery of a yoga class. Strategies such as providing more information on yoga and its benefits, and organizing taster sessions or introductory classes were suggested to promote yoga in this population. These findings would be useful to persons interested in yoga for an older population, and should be considered while developing a yoga programme.

Keywords: Physical activity; Focus groups; Interviews; Muscle strengthening; Balance

Abbreviations

PA: Physical Activity; UK: United Kingdom; YP: Yoga Participants; NYP: Non-Yoga Participants; IPAQ-SF: International Physical Activity Questionnaire-Short Form; COREQ: Consolidated Criteria for Reporting Qualitative research

Introduction

In 2016, older adults (65+ years) comprised 8.4% of the world population [1]. This is projected to increase to 11.6% by 2030 [2]. In Scotland, older adults comprise 18% of the population, and the projected growth-rate for the 65-74 years and 75+ years age groups are 37% and 86% respectively by 2037 [3]. There is strong evidence to show that participating in Physical Activity (PA) is associated with numerous physical and psychological benefits for older adults [4-9]. In the United Kingdom (UK), PA guidelines for this age group include the accumulation at of least 150 minutes of moderate intensity activity or 75 minutes of vigorous activity per week, as well as activities to improve muscle strength, and balance and coordination on at least two days a week [10]. Recent data from Scotland suggests that 53% of men and 66% of women aged over 65 years did not meet the moderate to vigorous intensity recommendations [11]. Moreover, only 19% of older men and 12% of older women met the balance and co-ordination guidelines [12]. The percentage of the Scottish population meeting muscle strengthening guidelines decreased with age, with only nine percent of men and four percent of women over 75 years meeting the guidelines [12]. It is therefore important to develop and implement strategies to increase participation in these activities for this population.

Yoga has been suggested by the UK government to help older adults achieve the muscle strengthening guidelines [13]. In older adults, yoga has been found to improve physical and mental health status [14], including flexibility [15-17], strength [15,16,18], and balance and mobility [18-20]. Yoga has also been found to significantly reduce depressive symptoms, improve sleep quality [21] and enhance executive function [22]. Despite these benefits, only 2% of the Scottish population aged 65-74 years, and 0% of the 75+ age group participated in yoga or pilates in 2014 [23]. Women are more likely to participate in yoga than men [24], and male participation rates in yoga or pilates are extremely low in Scotland [23].

Formative evaluation is a crucial aspect of programme development and evaluation, and involves consultation with stakeholders and the target population to identify elements that are likely to be effective in the programme [25]. Two studies provide information on yoga practice while working with older adults. One study used a validated survey to understand the benefits, barriers and cues to participating in a yoga programme among older adults [26]. Another study drew upon the author's experience as a yoga teacher and researcher to provide guidelines to promote psychological health in older adults [27]. However, the lack of qualitative studies providing deep and rich information on older adults' views of yoga is evident.

Citation: Sivaramakrishnan D, Fitzsimons C, Mutrie N and Baker G. Perceptions of Yoga among Older Adults: A Qualitative Approach. Ann Yoga Phys Ther. 2017; 2(4): 1035.

This study seeks to address this knowledge gap by using qualitative techniques to understand the perceptions of yoga among males and females over 65 years, from a mixed sample of participants with and without prior yoga experience. The aim of this study is to:

1. Explore the perceptions of yoga in adults over 65 years
2. Understand why yoga is a female dominated activity
3. Provide guidance for yoga instructors
4. Provide strategies for promoting yoga in the older adult population

Methods

Participants

Male and female participants from Edinburgh, Scotland were recruited through convenience sampling, including those with previous yoga experience or currently practicing yoga (Yoga Participants, YP), and those who had not done yoga in the past five years (Non-Yoga Participants, NYP). The study inclusion criteria were that the participants should be 65 years and above, and should be able to speak and understand English. For the YP group, the number of years of yoga practice was not a criterion for recruitment. Participants with yoga experience were recruited from yoga classes at a local leisure centre, and a university fitness facility. Participants for the NYP group were recruited through programmes for older adults run by a local leisure centre. The lead author made announcements regarding the study at these venues, and approximately 30 people expressed an interest in participating. Interested participants were given a study information sheet describing the study objectives and what participation in the study would entail, and any questions raised were answered. Approximately 37% dropped out due to unavailability on the suggested dates. All participants gave written informed consent, and ethical approval for the study was obtained from an institutional ethics committee.

Instrumentation and data collection

Focus group sessions were initially considered the appropriate method for collecting data, as interaction among participants would yield richer information [28]. The recruitment of non-yoga participants and men proved challenging. Hence, data collection procedures were amended, and a mix of focus groups and interviews were conducted with these participants. The data were collected between November 2016 and March 2017. The sessions were conducted at the venues where the yoga classes were held, and at the location where some leisure centre programme members had their regular meetings.

Similar but separate topic guides were developed by the primary researcher for the YP and NYP groups, and were reviewed by a panel consisting of the authors and 3 external members with diverse experience relating to yoga, physical activity research and health. The guides (Appendix 1, 2) were revised based on suggestions from the panel. The topic guide for the YP group had questions relating to overall experiences with yoga, and the benefits and challenges, whereas the NYP group topic guide enquired about the potential benefits and apprehensions with yoga. Pictures of a yoga class and a two-minute video of yoga stretches were shown during the session to stimulate discussion. All focus groups/interviews were moderated/conducted by the lead author (DS), with a co-moderator present for the focus groups. The moderator and co-moderators were all female. At the time of the study, the primary researcher was pursuing a PhD. She has a Masters in Sport and Health Sciences, and has undertaken formal training in conducting qualitative research. She is also an experienced yoga teacher.

Before the session commenced, participants were requested to fill out a brief questionnaire to record age, gender and yoga experience. They also completed the short version of the International Physical Activity Questionnaire (IPAQ-SF) [29], which captured information on time spent walking and performing moderate and vigorous intensity activities. Participants were then categorized into low, moderate or high physical activity levels using the scoring protocol for the IPAQ-SF (Appendix 3). All sessions were audio recorded. Additional notes were taken during the sessions, and a brief discussion between moderator and co-moderator ensued after the focus group sessions.

Data analysis

Thematic analysis [30] was used to analyze the transcripts, following the suggested step-by-step process. The first step was familiarization with the data. The focus group and interview recordings were transcribed verbatim either by the lead author or an external professional transcription company. Transcripts were read through several times. For step two, three researchers (DS, CF, GB) conducted line-by-line coding of one transcript. Initial codes were then generated by the primary researcher for all transcripts, and were transferred to a computer software package (Nvivo 11 for Windows). The third and fourth steps included searching for themes and refining them, and the software was used to manage the codes and thematic structure through this process. For the fifth phase, the essence of each theme was discussed by all authors to define and finalize these. Within some themes, framework analysis [31] was used to explore the differences in perceptions between the yoga and non-yoga participants. The software package was used to summarize data into a matrix that allowed for comparing the views of YP and NYP groups across themes and sub-themes.

The notion of rigor in qualitative research is evolving. Researchers have questioned the use of concepts like member checking or participant validation and inter-rater reliability to judge the accuracy and credibility of qualitative analysis [32]. In this study, rather than researchers independently coding data, and then coming to an agreement over the codes, they acted as critical friends [32], where dialogue and discussions guided the coding and analysis process. The COREQ checklist (Appendix 4) was adhered to while reporting on this study [33].

Results

Participant characteristics

A total of 19 participants attended the sessions (Table 1), and 3 focus groups and 5 interviews were conducted. It was difficult to recruit sufficient men to organize focus group discussions therefore interviews were conducted with male participants. The average age of the participants was 74 years (range: 65-84 years). Forty-two percent of the participants reported high physical activity levels, 32% reported moderate levels, and 21% reported low levels. The average duration of

Table 1: Number of study participants by gender, yoga experience and attendance at focus groups or interviews.

	Gender				Total
	Female		Male		
Yoga experience	Focus groups	Interviews	Focus groups	Interviews	
Yoga participants	9	0	0	2	11
Non-yoga participants	4	1	0	3	8
Total	14		5		19

the sessions was 55 minutes (standard deviation: 11).

Themes were identified and categorized under four broad topics (Figure 1 & Appendix 5): perceptions of yoga, gender, guidance for instructors, and strategies for promoting yoga.

Perceptions of yoga

General perceptions about yoga: Participants from both groups felt that yoga was an activity that was suitable for older people for a number of reasons. It was described as a good, all-round workout for an older person. As described in the following quote (female, YP), participants felt yoga was something that you could continue to do at their stage of life-

"..All of us probably did hockey or netball or something else. Obviously, at our age we don't rush around playing netball or tennis as much. And yoga is something that you can do."

They felt that yoga was inclusive, not too strenuous, and unlike many other activities, did not need much preparation.

Participants with yoga experience perceived it as a body and mind activity that brought breathing and movement together. They were aware of the different types of yoga, and its physical, mental, relaxation and spiritual dimensions. They had a very positive view of yoga, and expressed that they enjoyed and loved doing yoga. Another perception that came through strongly was the non-competitive aspect of yoga. The YP group described yoga as a journey where you don't force yourself, and do it to your own ability. One participant (male, YP) reflected-

"The great thing about yoga is that each person goes to what the teacher calls your edge. You should go to your edge and not beyond it. Different people have different edges for different postures."

The yoga participants also felt that while you may feel embarrassed if you fall in other classes, this does not upset you in a yoga class.

Some participants in the YP group described yoga as a different form of exercise, in that it is not a regimented activity, and works on the body differently from other exercises. One male participant felt that after a yoga class you feel you've exercised to the same degree as marching, and have exercised all your muscles.

Among the NYP group, many participants said that they did not know a lot about yoga, and were unsure about the different styles. A few were aware of yoga as it had been advertised in libraries and churches. One participant (male, NYP) was knowledgeable about the concept of yoga-

"So for me yoga has been how you combine physical positions with a beneficial way of meditating and thinking about the deeper matters of life."

Both groups viewed yoga as an activity that's not too vigorous, and slower and easier compared to other activities. However, some non-yoga participants perceived yoga as something one does on the floor, to do with sitting and not associated with movement.

Benefits of yoga: Participants who had done yoga felt that it was beneficial on many levels as evidenced by this quote (female, YP)-

"I think it brings three benefits to me…it's the physical fitness postures which stretch you and keep you flexible, maybe not as flexible as we used to be but at least it stops you getting worse, and secondly, it's a sort of emotional balance and harmony,…relaxation is great, and the third part…that's the meditation and the concentration on the inner self, which is interesting."

The yoga participants described the benefits of yoga in detail:

Physical benefits: The YP group felt that yoga helped keep fit and improved flexibility, suppleness, strength and balance. They also felt that yoga helped with other sports and activities like badminton. Good posture was seen as a major benefit. Participants also expressed that yoga helped with joint and back problems, to ease pain, and aided recovery from any problems one might have. One participant felt that yoga helped her prepare, and recover from hip replacement surgery, and felt it gave her the confidence to do things post-surgery.

Mental benefits: Yoga was thought of as calming and peaceful by yoga participants. They felt that it relaxed them, and enabled them to sleep better. Yoga was found to be good for the mind, stimulated thought, and taught concentration. These older adults felt that yoga improved their self-efficacy and participants felt that they were learning, getting better with some postures, and were surprised when they found they could do some of the yoga poses.

Benefits of breathing: Many yoga participants liked the meditative and spiritual aspects of yoga, as well as the breathing. They found that breathing was invigorating and relaxing. It had a calming effect and helped get rid of worries. It helped get a grip of oneself, and hence could be used during a visit to the dentist, or while getting an injection.

The NYP group named some but not all of the above benefits of yoga. They felt that yoga was good for the body and mind, and could help with sleep difficulties, and sore backs and knees. Improved strength, balance, coordination, flexibility and toning were also mentioned as perceived benefits by the NYP group.

Apprehensions: The non-yoga participants expressed many apprehensions with regard to taking up yoga. Male participants felt that yoga was not aerobic enough, circulation and muscles would not be challenged, and that no sweating would occur. Yoga, they felt was about a higher level of suppleness not really necessary for everyday life.

The non-yoga group also anticipated that they would struggle with yoga, they would find it difficult and demanding, and wouldn't be able to do many of the exercises. Holding a posture, which might lead to cramps, and balance exercises were regarded as particularly challenging. Some perceived yoga as contortions and difficult

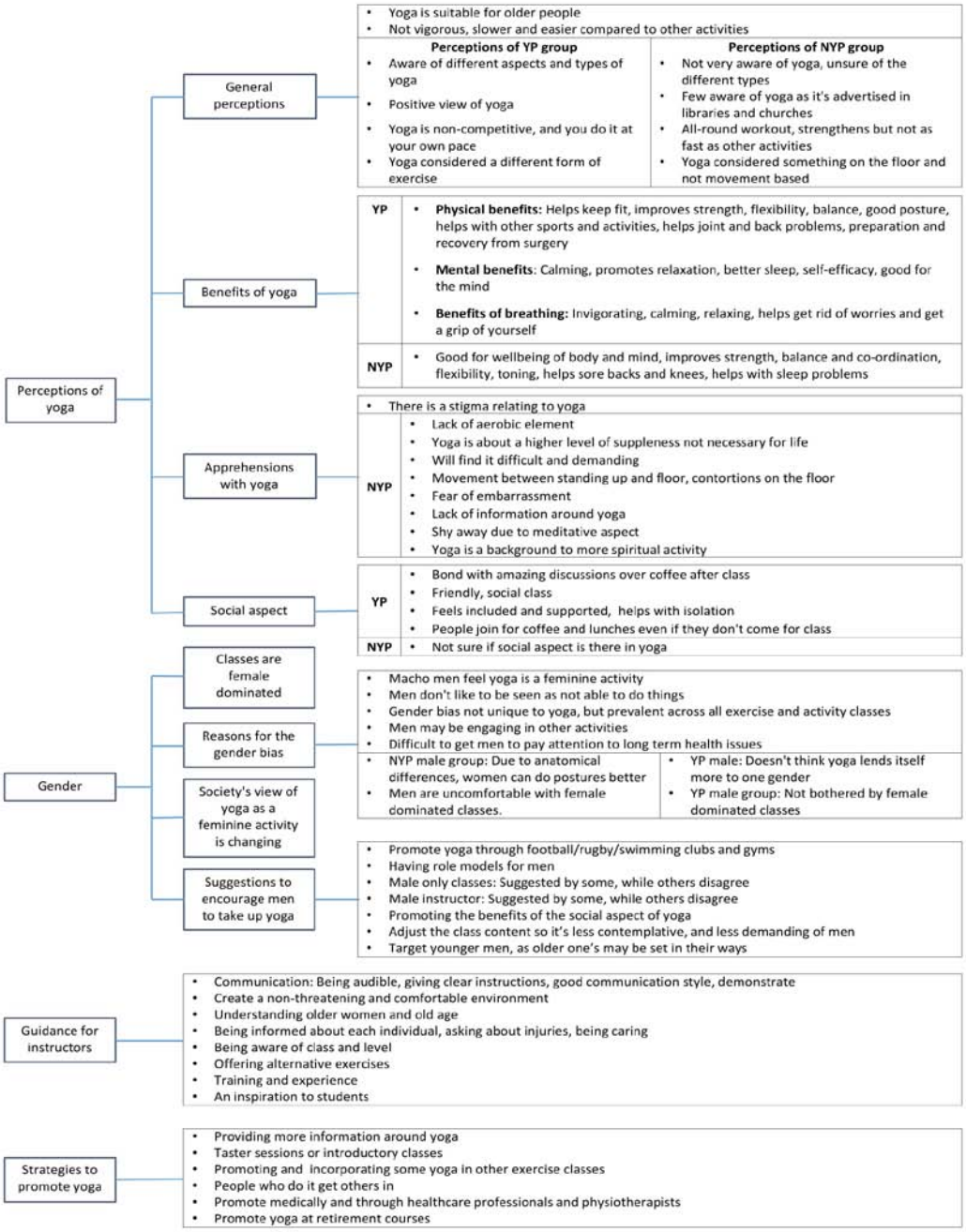

Figure 1: Perceptions of yoga in older adults: Themes and sub-themes.
YP: Yoga participants, NYP: Non-yoga participants.
Themes pertain to all participants unless otherwise specified.

positions as expressed by a female, non-yoga participant-

"I think if the word yoga was in it, I wouldn't be interested because you have a different perception of yoga…because all I've ever seen about yoga or known about yoga is difficult positions on the floor."

Some non-yoga participants felt that they would be embarrassed in class if they couldn't do the things asked of them. They were also worried about getting down and up from the floor during a class.

Lack of information about yoga was a huge barrier to participation. One non-yoga participant felt that people don't intuitively know what to expect with yoga, in contrast with swimming or walking. Moreover, it was not clear what types of yoga would be suitable for older people.

Participants from both groups indicated that there might be a stigma around yoga. Yoga could have religious connotations, projecting an image of someone sitting cross-legged. Phrases like "airy-fairyness", "for the flower power people" or "for the third age" were used to describe the impression some people may have of yoga. Non-yoga participants viewed yoga as a background to spiritual

activity, and shied away as they thought it would have considerable meditation and spiritual content.

Social aspect: The yoga participants stressed the value and importance of social interaction. They felt that the yoga class was friendly and social, and they immensely enjoyed the discussions over coffee after classes. They also reported that some people who gave up the class still joined for coffee and lunches. The social bonding helped them feel included and supported. The participants in the two focus group sessions knew each other very well as they had been doing yoga together for a long time. The friendship and affection between them was evident. This quote (female, YP) shows that the effects and benefits of yoga go beyond the studio to make a deep and lasting impact-

"All of us have had things that have happened, life-changing things, like ten years ago I had my breast cancer and I was off yoga and all the other classes for a year. And the yoga teacher sent me some sheets, printouts of exercises, mostly breathing exercises, and that sort of thing, and that was lovely because I did them and I felt still included in the group, and others have perhaps lost husbands or illnesses and things, and we all have supported each other through that. Phone calls and letters…"

However, the non-yoga participants thought that the social aspect may be missing with yoga. Unlike walking where you interact during the activity, yoga was perceived as an individual activity like swimming.

Gender

The yoga participants observed a preponderance of women in yoga classes. Reasons for this gender bias were discussed by all participants, and an emerging critical factor was that it may be considered a feminine activity. Both groups expressed the view that older men still had a macho man attitude and regarded yoga as a "cissy" activity. Men may also be more self-conscious and don't want to be seen as unable to do something. Some men suggested that yoga was more suitable for women as they have a degree of suppleness that men don't have. One male yoga participant disagreed with this view. While some men found it uncomfortable to attend classes dominated by women, the two male yoga participants did not seem bothered by this. Although one of them admitted that before he started yoga, he had a perception that it was something that women did.

Another idea discussed was that the gender bias was not unique to yoga, but was prevalent across all exercise and activity classes. One reason offered was that men did not like to join groups and preferred individual activities, while women were more social. Finally, the difficulty of getting men to pay attention to long-term health issues was discussed.

Participants observed that society's view of yoga as a feminine activity was changing, with football and rugby clubs introducing yoga, and young male students joining yoga classes. They offered some suggestions that would encourage men to take up yoga: promoting and delivering yoga through gyms, rugby, football and swimming clubs, and having role models could make yoga more appealing to men. Conducting male only classes and having a male instructor was advocated by some, and dismissed by others. One male non-yoga participant suggested that men need a soft entry to yoga, so that they enjoyed the activity, built a social circle and felt the benefits of the social aspect of yoga. Finally, targeting younger men was suggested as older men may be too set in their ways, and it may be difficult to persuade them to join.

Guidance for instructors

Participants highlighted several qualities they would like in an instructor. They also offered suggestions on teaching methods that would facilitate the effective delivery of a yoga class.

The communication style adopted by instructors during a yoga class emerged as a significant theme. It was extremely important to participants that the teacher was audible, and they expressed frustration when the teacher spoke quietly. They wanted instructors to give clear and precise instructions, and provide explicit directions for each body part. They felt it was important for instructors to demonstrate, as they found that understanding movements on different sides of the body was confusing if no visual demonstration was provided. They also found it difficult to watch the instructor and do the postures at the same time, and hence felt that the instructor should first demonstrate and then they would follow.

In line with yoga being perceived as non-competitive, it was felt that the instructor should create a non-threating and comfortable environment, where one is not forced to do anything. This is evident in the following excerpt from a focus group session (females, NYP)-

Participant 1: You have to be reminded that, that's okay. If that's as much as you can do, that's okay.

Participant 2: To take the lower option.

Participant 1: And you don't feel embarrassed and you don't feel, well, I can't keep up with them so I'm not going to go anymore.

Participant 3: Yes, you've got to do it at your own pace.

Participants stressed that an instructor should be sympathetic, patient, approachable and encouraging. They appreciated it when instructors were caring and took an interest in each individual, asking about injuries and health problems. Hence being aware of the class and their abilities was important to participants, who were put off if they were taxed beyond their capabilities. Participants emphasized the importance of offering alternative exercises while working with older people, using props like chairs or providing easier options. They valued training and experience in a teacher.

A male yoga participant said that he hurt himself in yoga on one occasion, which may have been caused by the instructor giving him a push while in a yoga pose. Since instructors may not be aware of the physical condition of every student, it may be prudent for them to abstain from manually correcting the postures, and instead provide verbal feedback.

Strategies for promoting yoga

Participants from both groups suggested some strategies to overcome apprehensions and promote participation in yoga.

Providing more information around yoga and publicizing the benefits would assuage some of the fears of non-yoga participants, who felt they maybe more motivated to join if they understood the benefits. Non-yoga participants were keen on yoga tasters and

introductory sessions, so that they could try and see if it was for them. Introducing a bit of yoga in other exercise classes was another strategy suggested. It was recognized that people who do yoga had a big role to play in encouraging partners and friends to join. Although this has not always been successful, many in the yoga group were themselves brought in by people they knew, and hence experienced a degree of comfort while joining.

Participants felt that yoga could be promoted more by healthcare professionals and physiotherapists to address medical issues. The following quote (female, YP) elaborates the premise and reason behind this suggestion.

"*I also think medically they could promote it some more. Because I have arthritis, basal arthritis. Now, they wanted to immediately give me injections, and with an operation in two years' time. And I said no, I want you to give me a series of exercises. Which they have done. And I went back last week, and she said the injections are really working. I said I haven't had the injections. She never suggested exercises. And I think medically, they could suggest. That's the first, try it, and if it doesn't work then move on to the next.*"

Finally, promoting yoga during retirement courses using videos and demonstrations was suggested.

Discussion

The study offers an in-depth understanding of how yoga is perceived among older adults with and without yoga experience. A key finding was that yoga was viewed as a suitable activity for older adults by all participants, as it is slow, gentle and not strenuous, and could be practiced as they aged.

The YP group reported that practicing yoga had many physical and mental benefits, and some of these were also perceived by the NYP group. Perceived benefits like improved strength, balance, posture, sleep, mental ability, relaxation, help with joint problems, and social benefits have been reported by another study [26]. The study also reported benefits like lowered blood pressure, immune response and preventing chronic fatigue which were not mentioned by the participants in the current study. This could be due to the differences in data collection methods, as the other study administered a validated survey. Intervention studies confirm that yoga is effective in improving some of these mentioned parameters like strength, balance, flexibility, pain management and sleep [15-21]. Participants in the current study mainly mentioned observable benefits that improve day-to-day living and quality of life. They did not seem aware of yoga's beneficial effects in improving medical conditions such as diabetes [34], and cardiovascular risk factors [35].

Feeling intimidated has been identified as a barrier to physical activity participation in older adults [23,36]. This is an issue that yoga could transcend as the YP group stressed on its non-competitive aspects, and stated that they don't feel embarrassed during a yoga session. However, results indicate that the non-yoga participants viewed yoga as difficult contortions on the floor, and felt they may be embarrassed if they couldn't do some of the postures in class. This perception could be altered by providing more information on yoga as an activity that is suitable for people of all fitness levels and capabilities. Quotes from yoga participants emphasizing the non-competitive and non-judgmental aspects of yoga could be used in promotional material. This could also be addressed by instructors who could offer alternative exercises and props, and ensure that the pace and intensity of the class is suitable for a range of abilities. Since non-yoga participants were apprehensive about the meditation and spiritual aspects, careful consideration should be given to the inclusion and presentation of these elements during intervention development and promotion. It would also help to increase awareness of the benefits of breathing and meditation.

In the current study, it was noted that some gender issues may not be specific to yoga, and may actually relate to the attitudes that older men have towards long-term health issues and joining group activity classes. Although some participants were of the opinion that older men were set in their ways, some ideas to overcome gender issues were suggested.

Instructor quality has been previously reported as a perceived barrier to yoga participation [26], and the current study is able to offer guidance for instructors to consider while working with older adults. Some identified themes pertaining to instructor qualities are validated in a study [27] providing guidelines to promote psychological health in older adults. Similar to current findings, the study [27] suggested that instructors use positive and encouraging words, and provide chairs to students who need support. It also encourages verbal rather than physical correction. With respect to demonstrating, the study suggested that instructors mirror their students to avoid confusion about movement on left and right sides.

Implications for practice and future research

Although research evidence suggests that yoga has the potential to improve health outcomes in older adults, studies with larger sample sizes and rigorous reporting are required to establish the effectiveness of yoga, as well as the optimal intensity and frequency of yoga practice [14,19]. The findings of this study can aid future research by informing intervention development. Men in the NYP group felt that yoga would not be challenging aerobically, and this theme was also reported by another study [26]. In this context, it is important to educate them about strength and balance guidelines, as well as yoga's effectiveness in improving these outcomes. This study forms a part of the body of research aiming to increase adherence to muscle strengthening, and balance and coordination guidelines in older adults. Systematic reviews and meta-analysis to establish the evidence base and understand contraindications of yoga for this age group would also facilitate this endeavor. Another benefit mentioned by yoga participants is that yoga is instrumental in preparing and recovering from surgery. While there is some research evidence to show that yoga has scope as a rehabilitative tool [37,38], more research evidence is required for yoga to be actively promoted by healthcare professionals and physiotherapists.

Strategies to overcome barriers and encourage yoga participation have been compiled. The study thus serves as a practical guide to yoga instructors, other teachers working with older adults, researchers and programme developers.

Strengths and limitations

This is the first study to use qualitative techniques to understand the perceptions of yoga in older adults, and as a result offers new

and nuanced findings. One of the study's strengths is that it captures and provides analyses of the views of older adults with no prior yoga experience, to identify barriers to participation. Another is that the study makes practical recommendations which have implications for research and practice. The study has some limitations. The sample size may not be representative in terms of socio-economic, geographical and physical activity characteristics of older adults in Scotland. As it proved difficult to recruit men and non-yoga participants, they form a smaller proportion of the overall sample. Persons averse to yoga may not have been interested in participating in the study, and hence their views may not be adequately represented. Due to time and resource constraints, we could not ensure that data saturation was achieved.

Conclusion

Yoga was viewed as a slow, gentle activity, suitable for older adults. Yoga participants had a positive view of yoga and appreciated its non-competitive aspect. However, some participants with no yoga experience anticipated they may find it too demanding, and perceived it as contortions on the floor. The gender bias was ascribed to male attitudes like characterization of yoga as a feminine activity, preference for individual rather than group activities, and lack of attention to long-term health issues. Guidelines for yoga instructors working with older adults include being audible, giving clear instructions and demonstrating in class, creating a non-threatening environment, being aware of the level of the class, offering alternative postures, and using props when required. Providing more information on yoga and its benefits, and organizing taster sessions were suggested strategies to overcome barriers and promote yoga in the older adult population. These insights and strategies would be helpful to researchers, instructors, yoga studios, fitness centers, and programme developers, and should be considered while designing a yoga programme.

Acknowledgement

The authors would like to thank Dr. Tasneem Irshad, Dr. Yvonne Laird, June Adamson, Claire Craig, Marshall Dozier, Sheena Taylor, and all participants for their contributions to this study.

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Ann Yoga Phys Ther - Volume 2 Issue 4 - 2017
ISSN: 2573-8585 | www.austinpublishinggroup.com

Citation: Sivaramakrishnan D, Fitzsimons C, Mutrie N and Baker G. Perceptions of Yoga among Older Adults: A Qualitative Approach. Ann Yoga Phys Ther. 2017; 2(4): 1035.

Appendix 16. Participant information sheet for Study 2

PARTICIPANT INFORMATION SHEET

You are invited to take part in a research study undertaken by the Physical Activity for Health Research Centre at the University of Edinburgh. Before you decide whether or not to take part, it is important that you understand why the research is being done, and what it will involve.

What is the purpose of the study?

The perception of yoga among adults who are 65 years and older in Scotland, UK has not been studied. The main aim of this study is to understand how yoga is perceived by adults who are in the 65 years and above age group. This study will help develop and deliver a yoga programme for older adults.

Why have I been invited?

Since you're an adult who is in the 65 years and above age group, we would like to invite you to participate in this research study.

Do I have to take part?

No it is up to you to decide. You can take your time to read the information, ask questions, and talk to your friends/family to help you decide. Even if you decide to take part, you can withdraw from the study at any time, without giving a reason.

What will happen if I take part?

Once you have decided you would like to participate, you will be invited to take part in one group discussion to understand your perceptions of yoga. You will be part of a group of about 4-8 members. You will first have to fill in a questionnaire booklet which will take approximately 6 minutes. This will be followed by the group discussion. A researcher will guide the session and encourage discussion about yoga, as well as your views on a yoga programme. You will be shown some pictures and your thoughts around these will be discussed. The session will be approximately 1.5 hours long and will be audio-recorded.

The group discussion will be held in a location and at a time that is most convenient to the majority of participants in the group. Tea, coffee and biscuits will be provided.

What are the possible benefits of taking part?
There are no direct benefits to taking part. However, the results of this study will help in the development of a yoga programme that is appealing and appropriate for older adults.

What are the possible disadvantages and risks of taking part?
We do not perceive there to be any risks to taking part in the group discussion.

What will happen to the information that I provide?
We will carry out this study in accordance with good practice guidelines regarding participant confidentiality and data protection. Data from audio recordings and written transcripts will be stored securely at the University of Edinburgh. Only researchers involved in this study will be able to access them. When we publish the findings of this research we may quote from your interview or focus group discussion, but if we do this it will be in such a way that your identity is safe. At the end of the project, transcripts with individual identifiers removed may be made available for other researchers to use.

What will happen to the results of the study?
The information collected and quotes from this discussion will be included in a PhD thesis, published in research papers and presented in scientific conferences and seminars. We will also provide you a summary report.
What if there is a problem?

During the study please contact a member of the research team if you have any questions.

- You can contact Divya Sivaramakrishnan on 07922804462 or email: s1460453@sms.ed.ac.uk

- You can contact Dr. Claire Fitzsimons on 0131 651 6049 or email: claire.fitzsimons@ed.ac.uk

If you wish to complain, or have any concerns about any aspect of the way you have been approached or treated during the course of this study, please contact Prof. Nanette Mutrie who is the Director of the Physical Activity for Health Research Centre [PAHRC], University of Edinburgh on +44 (0)131 651 6532 or email: nanette.mutrie@ed.ac.uk.

What happens next?
If you would like to participate in this group discussion, please read and sign the consent form provided to you. A researcher will contact you to find a suitable time and venue for the group sessions. You will be notified once the date and venue are finalised. Let us know if you would like us to remind you on the day before the session, and we would be happy to give you a reminder call. After this you just have to come to the session on the day and time specified.

Thank you very much for taking the time to read this information.
For more information, or if you have any questions, Please contact:
Divya Sivaramakrishnan
2.23 St Leonard's Land
Holyrood Road
Edinburgh EH8 8AQ
S1460453@sms.ed.ac.uk
07922804462

Appendix 17. Consent form for Study 2

PARTICIPANT CONSENT FORM

	Please read the following statements and initial the box in response	Please initial box
1	I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
2	I understand that participation is voluntary and that I am free to withdraw at any time, without giving any reason and without any consequences.	
3	I understand that the interview will be audio-recorded and transcribed.	
4	I understand and agree that the data collected including quotes will be used for a research thesis, and will be published in scientific literature and presented at scientific conferences. I understand that all data will be anonymised.	
5	I agree to take part in this study.	
6	I understand that personal information collected will be stored securely on University of Edinburgh premises.	
7	I understand that the information collected about me will be stored in a confidential and anonymous electronic database, which may be used to support other research in future, and may be shared anonymously with other researchers.	

8	I consent to future contact regarding possible participation in further research arising directly from this study. I understand that this will not commit me to taking part in further research.	☐

_____	_____	_____
Name of Participant	Date	Signature

_____	_____	_____
Name of person taking consent	Date	Signature

Appendix 18. Ethics approval letter for Study 3

Sav

MHSEthics@ed.ac.uk
To: s1460453@sms.ed.ac.uk
Moray House Research: Student Ethics Application (Supervisor approval granted)

28 September 2016 3:52 pm
Focus Group

M

Your supervisor or relevant programme sub-committee has approved your Ethics Application and it has been submitted to the School Research and Knowledge Exchange (RKE) Office for their records.

A standard condition of this ethical approval is that you are required to let your supervisor and the RKE Office know of any significant proposed deviation from your original research plan. To do this, please speak to your supervisor, and contact Shona Cunningham (MHSEthics@ed.ac.uk).

You should also inform your supervisor and the RKE Office if there are any unexpected results or events once the research is underway that raise questions about the safety of the research.

Before starting your data collection you must ensure that you have full approval from your supervisor for the project (design, method) and that you are eligible to proceed to the PhD/EdD dissertation phase.

Good luck with your project.

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The University of Edinburgh is a charitable body, registered in
Scotland, with registration number SC005336.

Appendix 19. Topic guide – Yoga participants

Introduction

1. Welcome to the discussion. Thank you very much for participating today
2. Introduce myself and co-moderator
3. The reason we're conducting these discussions is to understand your perceptions of yoga. We would like your input on this and want you to share your honest opinion with us. There are no right or wrong answers, and we would like everyone to participate in the discussion.
4. We will be audio recording the discussion. What you say will be confidential and stays in this room. We won't identify anyone by name in our report.
5. You are free to leave at any time with no consequences

Section	Theme	Group1- Done yoga previously	*Prompts*
Section 1	**Perceptions of yoga and nomenclature**		
	Overall perceptions	I would like to start by showing you some pictures **(Visual 1 & Visual 2)** What comes to your mind when you see these pictures?	*What do you think is happening here?*
	Yoga experience	All of you have done yoga before, could you tell me about your overall experience with yoga	*How long have you been attending the class?* *What did you enjoy when you did yoga?* *Physically?* *Mentally?* *What are some of the challenges with yoga?* *What do you think would have made the class better?*

	Nomenclature	What do you feel about the name of the class?	*Would another name be more appealing?* *What do you think a class like this will be called in a fitnes centre?* *What do you feel about it being called mindfulness?* *Would you attend a class called mindfulness exercises?* *What would you expect from this class?*

Section 2	**Class particulars**		
	Frequency	Let's talk about your ideal yoga class: How many times a week would you like to attend a yoga class?	
	Duration	How long do you think a class should be?	*More or less than an hour?*
	Participants	How many participants in a class do you think is appropriate?	*What do you think is a good group size?* *Is 15 a comfortable size?*
	Instructor	What kind of qualities would you like in a yoga teacher?	*What should a teacher do in class you make you more comfortable?*

Section 3	**Home-based component**		
	Overall thoughts	What are your thoughts on a home-based component to a yoga programme?	*What do you think are the positives and negatives of a home-based programme? Would you have the space at home for this?*
	Strategies to improve adherence	I would like to hear your ideas on some strategies that would help you stick to the programme and practice it regularly at home.	*Meeting as a group, calls from instructor*
	Materials required	I am now going to show you a short video **(Video 1)** What do you feel about doing yoga at home along with an instructional video like that?	*What material would help you practice yoga by yourself at home? Would handouts be useful? Do you have home internet? Are you comfortable accessing videos at home?*

Section 4	**Gender**		
		Do you see more men or women in a yoga class? Why is this?	*How do you think we could encourage more men to attend a yoga class?*

Appendix 20. Topic guide – Non-yoga participants

Introduction

1. Welcome to the discussion. Thank you very much for participating today
2. Introduce myself and co-moderator
3. The reason we're conducting these discussions is to understand your perceptions of yoga. We would like your input on this and want you to share your honest opinion with us. There are no right or wrong answers, and we would like everyone to participate in the discussion.
4. We will be audio recording the discussion. What you say will be confidential and stays in this room. We won't identify anyone by name in our report.
5. You are free to leave at any time with no consequences

Section	Theme	Group1- Done yoga previously	*Prompts*
Section 1	**Perceptions of yoga and nomenclature**		
	Overall perceptions	I would like to start by showing you some pictures **(Visual 1 & Visual 2)** What do you think is happening here? What comes to your mind when you see these pictures?	
	Yoga perceived benefits/barriers	I know that you haven't experienced yoga before, but what do you think would be the benefits to joining a yoga class?	*Do you think you would enjoy it?* *Is there any reason why you wouldn't join a class?* *Any apprehensions?*

	Nomenclature	Is the name of the class important in your decision to attend the class?	*Would another name make you more likely to be interested in the class?* *Any suggestions for another name?* *What do you feel about it being called mindfulness?* *Would you attend a class called mindfulness exercises?* *What would you expect from this class?*

Section 2	**Class particulars**		
	Frequency	If you were to attend a yoga programme, then ideally, How many times a week would you like to attend a yoga class?	
	Duration	How long do you think a class should be?	*More or less than an hour?*
	Participants	How many participants in a class do you think is appropriate?	*What do you think is a good group size?* *Is 15 a comfortable size?*
	Instructor	What kind of qualities would you like in a yoga teacher?	*What should a teacher do in class you make you more comfortable?*

Section 3	**Home-based component**		
	Overall thoughts	What are your thoughts on a home-based component to a yoga programme?	*What do you think are the positives and negatives of a home-based programme? Would you have the space at home for this?*
	Strategies to improve adherence	I would like to hear your ideas on some strategies that would help you stick to the programme and practice it regularity at home.	*Meeting as a group, calls from instructor*
	Materials required	I am now going to show you a short video **(Video 1)** What do you feel about doing yoga at home along with an instructional video like that?	*What material would help you practice yoga by yourself at home? Would handouts be useful? Do you have home internet? Are you comfortable accessing videos at home?*

Section 4	**Gender**		
		Who do you think is more likely to attend a yoga class- men or women? Why is this?	*How do you think we could encourage more men to attend a yoga class?*

Appendix 21. Scoring protocol for International Physical Activity Questionnaire Short Form (IPAQ-SF)

The activities assessed by the IPAQ-SF are walking, moderate-intensity activities and vigorous-intensity activities.

The items in the IPAQ-SF were structured to provide separate scores on walking, moderate-intensity and vigorous-intensity activity. Computation of the total score for the short form requires summation of the duration (in minutes) and frequency (days) of walking, moderate-intensity and vigorous-intensity activities. Domain specific estimates cannot be estimated.

All continuous scores are expressed in MET-minutes/week as defined below.

Formula for Computation of MET-minutes/week

Walking = 3.3 METs, Moderate PA = 4.0 METs and Vigorous PA = 8.0 METs. Using these values, four scores are defined:

Walking MET-minutes/week = 3.3 * walking minutes * walking days

Moderate MET-minutes/week = 4.0 * moderate-intensity activity minutes * moderate days

Vigorous MET-minutes/week = 8.0 * vigorous-intensity activity minutes * vigorous-intensity days

Total physical activity MET-minutes/week = sum of Walking + Moderate + Vigorous MET-minutes/week scores.

Categorical Score

Category 1 Low

This is the lowest level of physical activity. Those individuals who not meet criteria for Categories 2 or 3 are considered to have a 'low' physical activity level.

Category 2 Moderate

The pattern of activity to be classified as 'moderate' is either of the following criteria:

a) 3 or more days of vigorous-intensity activity of at least 20 minutes per day

OR

b) 5 or more days of moderate-intensity activity and/or walking of at least 30 minutes per day

OR

c) 5 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum Total physical activity of at least 600 MET-minutes/week.

Individuals meeting at least one of the above criteria would be defined as accumulating a minimum level of activity and therefore be classified as 'moderate'.

Category 3 High

A separate category labelled ‘high’ can be computed to describe higher levels of participation. The two criteria for classification as ‘high’ are:

a) vigorous-intensity activity on at least 3 days achieving a minimum Total physical activity of at least 1500 MET-minutes/week

OR

b) 7 or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving a minimum Total physical activity of at least 3000 MET-minutes/week.

Appendix 22. COQREQ checklist for Study 2

COREQ (COnsolidated criteria for REporting Qualitative research) Checklist

A checklist of items that should be included in reports of qualitative research. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Topic	Item No.	Guide Questions/Description	Reported on Page No.
Domain 1: Research team and reflexivity			
Personal characteristics			
Interviewer/facilitator	1	Which author/s conducted the interview or focus group?	3
Credentials	2	What were the researcher's credentials? E.g. PhD, MD	3
Occupation	3	What was their occupation at the time of the study?	3
Gender	4	Was the researcher male or female?	3
Experience and training	5	What experience or training did the researcher have?	3
Relationship with participants			
Relationship established	6	Was a relationship established prior to study commencement?	3
Participant knowledge of the interviewer	7	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	3
Interviewer characteristics	8	What characteristics were reported about the inter viewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	3
Domain 2: Study design			
Theoretical framework			
Methodological orientation and Theory	9	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	4
Participant selection			
Sampling	10	How were participants selected? e.g. purposive, convenience, consecutive, snowball	3
Method of approach	11	How were participants approached? e.g. face-to-face, telephone, mail, email	3
Sample size	12	How many participants were in the study?	4, 15
Non-participation	13	How many people refused to participate or dropped out? Reasons?	3
Setting			
Setting of data collection	14	Where was the data collected? e.g. home, clinic, workplace	3
Presence of non-participants	15	Was anyone else present besides the participants and researchers?	3
Description of sample	16	What are the important characteristics of the sample? e.g. demographic data, date	4, 15
Data collection			
Interview guide	17	Were questions, prompts, guides provided by the authors? Was it pilot tested?	3
Repeat interviews	18	Were repeat inter views carried out? If yes, how many?	N/A
Audio/visual recording	19	Did the research use audio or visual recording to collect the data?	3
Field notes	20	Were field notes made during and/or after the inter view or focus group?	3, 4
Duration	21	What was the duration of the inter views or focus group?	4
Data saturation	22	Was data saturation discussed?	11
Transcripts returned	23	Were transcripts returned to participants for comment and/or	4

Topic	Item No.	Guide Questions/Description	Reported on Page No.
		correction?	
Domain 3: analysis and findings			
Data analysis			
Number of data coders	24	How many data coders coded the data?	4
Description of the coding tree	25	Did authors provide a description of the coding tree?	16, Appendix 5
Derivation of themes	26	Were themes identified in advance or derived from the data?	4
Software	27	What software, if applicable, was used to manage the data?	4
Participant checking	28	Did participants provide feedback on the findings?	4
Reporting			
Quotations presented	29	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number	4-9
Data and findings consistent	30	Was there consistency between the data presented and the findings?	4-9, 16
Clarity of major themes	31	Were major themes clearly presented in the findings?	Appendix 5
Clarity of minor themes	32	Is there a description of diverse cases or discussion of minor themes?	4-9,Appendix 5

Developed from: Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. 2007. Volume 19, Number 6: pp. 349 – 357

Once you have completed this checklist, please save a copy and upload it as part of your submission. DO NOT include this checklist as part of the main manuscript document. It must be uploaded as a separate file.

Appendix 23. Themes and sub-themes for Study 2 with quotes

All themes and sub-themes including unique themes for the perception of yoga in older adults study

Note: a quote has been provided to illustrate each theme

Major themes	Unique themes
1. Perception of Yoga	
a. General perceptions about yoga	
(i) Yoga is suitable for older people- "I just feel it's suitable for older people who don't want to be jumping about, you know, in vigorous exercise" (female, NYP) "We can't be in a team game anymore because we're this age. It's something we can go on doing" (female, YP)	
(ii) Not vigorous, slower, gentle, and easier compared to other activities- "It is also comparatively easy compared to lot of the other activities for our age group" (female, YP) "I always connect yoga with being quite slow and fluid" (female, NYP)	
Perceptions of YP group	
(i) Aware of different aspects and types of yoga- "So, you associate your movements and the breathing, so get it all together" (male)	(i) All-round exercise , muscles have all been exercised- "but you certainly know that your muscles have all been exercised" (male)
(ii) Positive view of yoga- "I just love yoga" (female)	(ii) Does yoga for suppleness- "Well, there are three different kinds of exercise- suppleness, strength and stamina. And yoga is for suppleness. So that's why I do it." (male)
(iii) Non-competitive, do at your own pace, no embarrassment- "Yes, it's nice that it's supposed to be non-competitive, so we're not looking at everybody else, saying how do you manage to double yourself in knots?" (female)	
(iv) Yoga considered a different form of exercise- "Yoga it's different, and works on the body differently from all the other activities" (male)	
Perceptions of NYP group	
(i) Not very aware of yoga and unsure of the different types- "I think it's hard to say an awful lot at a point when I'm in fair degree of ignorance about what yoga is really all about" (male)	(i) Knowledgeable about the concept of yoga- "So for me yoga has been how you combine physical positions with a beneficial way of meditating and thinking about whatever, the deeper matters of life" (male)
(ii) Few aware of yoga as it's advertised in libraries and churches- "Well there's quite a lot of publicity. You see it in libraries, church halls, all the different yoga classes are on" (male)	(ii) Yoga is for developing suppleness- "I've always thought of yoga as being to do with, from a physical point of view, developing the suppleness of the body" (male)
(iii) All-round workout, strengthens but not as fast as other activity classes- "I think yoga is the kind of exercise that does strengthen but it's not vigorous exercises" (female)	

(iv) Something on the floor, sitting, not balance and exercise- “I always think that it’s something that you do on the floor” (female)	
b. Benefits of yoga	
YP group	
(i) Yoga is beneficial on many levels – “I just feel it’s very beneficial on many levels” (female)	
(ii) Physical Benefits	
° Helps keep fit- “..and I felt that I kept myself fit. It helped to keep myself fit” (female)	
° Stretching, flexibility and suppleness- “but certainly all your muscles feel stretched and feel nice..” (male)	
° Strength and balance- “it strengthens your leg muscles” (female)	
° Helps with other sports and activities- “I think yoga helps with any other sport. If you’re going to yoga, you’re going to be better able to play badminton,…” (male)	
° Good posture- “..the main thing I think of is posture. I think it helps you tremendously with posture” (female)	
° Helps with joint and back problems- “And, two years ago I had a joint problem, and I found it really helped I have yoga behind me” (female)	
° Helps with surgery, eases pain and aids recovery- “I had a knee replacement two years ago. I found doing yoga, practicing yoga helped to… through all the years, it was something I did like just in preparation for the operation.” (female)	
(iii) Mental benefits	
° Calm and peace- “My life is very hectic although I’ve retired for nearly six years…And certainly calming down for an hour once a week is beneficial, no question” (male)	
° Relaxation- “So yes, there is a mental benefit, because for that one hour I am relaxing mentally” (male)	
° Better sleep- “my previous class was an evening class. And I used to sleep most wonderfully well” (male)	
° Good for the mind- “…but doing yoga makes you think as well..” (male)	
° Self-efficacy- “..and then you were very pleasantly surprised when you could actually do something, standing on your head, or shoulders....That was very good” (female)	
° Other mental benefits- “..it gets me up in the morning, put it that way” (female)	
(iv) Benefits of breathing	

° Likes yoga breathing and the meditative and spiritual aspects- "I also like it for the yoga breathing exercises we do" (female)	° Helps with sleep difficulties- "..usually when I have something on my mind which interferes with my sleep, If I concentrate on yoga breathing for a while, I find that it sends me to sleep" (female)
° Invigorating, calming, relaxing- "It seems to be invigorating and at the same time, it relaxes you, which is a lovely feeling" (female)	
° Helps get rid of worries and get a grip of yourself- "..you try to get this breathing idea associated with your…whatever your circumstances are, to try to get a grip of yourself.." (male)	
NYP group	
(i) Good for wellbeing of body and mind- "..it's supposed to be good for one's wellbeing in terms of body and mind." (male)	(i) Sleep problems- "Sleep problems, especially in the summer time" (female)
(ii) Strength- "I presume it's good for core strength" (female)	(ii) Balance and co-ordination- "Co-ordination, so you're getting physical and mental workout" (female)
	(iii) Sore backs and knees- "Sore backs, sore knees." (female)
	(iv) Flexibility and toning- "I've heard that it's very good for flexibility and toning." (female)
c. Apprehensions with yoga	
(i) Lack of aerobic element – "The aerobic element is not really there" (male, NYP)	(i) Anxious about aggravating injuries to the spine- "I would just have to watch the…way the joints are in my back that I did damage…and I have damaged them, I wouldn't want to create any more damage to that…" (male, NYP)
(ii) Yoga is about a higher level of suppleness not necessary for life- "It's not that I wouldn't like to have a body that was more supple, it's just that it's supple enough for my day-to-day life" (male, NYP)	
(iii) Will find it difficult and demanding- " I suspect physically I would find it demanding" (male, NYP)	
(iv) Movement between standing up and floor, contortions on the floor- "...I would find that I might be able to get down but I'd find it very difficult to get up" (female NYP)	
(v) Embarrassment- "I think yoga is about, as I said, difficult positions on the floor, and you wouldn't want to be embarrassed, you know?" (female, NYP)	
(vi) Lack of information around yoga- "Just to understand what it is. I mean, there's never really much information around about it" (Male, NYP)	
Uncertainty regarding appropriate clothes and footwear- "And, sort of, what do you wear and…?" (female, NYP)	
(vii) Stigma- "But I do feel people that you tell about your yoga class look at you and think, is she a bit	

peculiar? There's a sort of stigma attached to yoga," (female, YP)	
(viii) Shy away because due to meditative aspect- "I tend to maybe shy away because it's trying to take you into this meditative state" (male, NYP)	(ii) Don't really need meditation- "I thought there was meditation in it which I probably don't really need. I mean, I'm quite happy within myself." (male, NYP)
(ix) Yoga is a background to more spiritual activity- "the word yoga implies that it's as much to do about meditation and spiritual things perhaps, as opposed to physical activity" (male, NYP)	
d. Social aspect in yoga	
(i) Bond with amazing discussions over coffee after class- "but the gathering afterwards when we go and have a coffee, and we've all been through this together, and it's just…we bond, even though we're all quite different" (female, YP)	
(ii) Friendly, social class- "It's a very friendly class" (male, YP)	
(iii) Feels included and supported, helps with isolation- "But I think if there was anybody who was isolated or..it combines the exercise part, the yoga part with meeting people. Which if you're thinking of our age group is important" (female, YP)	
(iv) People join for coffee and lunches even if they don't come for class/ if they've left the class- "People come to the coffee if they can't come to the class for some reason" (female, YP)	
(v) NYP: Not sure if social aspect is there in yoga- "I don't know how much the social aspect is in that. Maybe not. Maybe just put people…turn up, do the course…" (male, NYP)	
2. Gender	
a. Classes are female dominated- " It's not the place to come to meet men" (female, YP)	
b. Suggested reasons for gender bias:	
(i) Macho men feel yoga is a feminine activity- "And at least in our society yoga is looked on as more feminine" (male, NYP)	
(ii) Men don't like to be seen as not able to do things- "Men don't like to be seen not being able to do things. That's what it comes down to" (male, NYP)	
(iii) Due to anatomical differences, women can do postures better- "There are lots of positions that a woman, because of their physical capacity can do much more readily than men" (male, NYP)	(i) Disagreement with the view that yoga is more suited to one gender- "I don't think it lends itself more to one gender than another, no. The exercises are capable of being done by both sexes" (male, YP)
(iv) Uncomfortable with female dominated classes- "But there are sometimes only one or two men in the whole class. And in a sense... I feel a bit uncomfortable if I'm the only man in the class" (male, NYP) YP male group were not bothered by female dominated classes- "In the past, I've attended a yoga class where I've been the only man. It doesn't bother me. I don't care" (male, YP)	(ii)YP male- perception of yoga before joining was that it was a female activity

(v) Gender bias not unique to yoga, but prevalent across all exercise and activity classes- "I mean even the other class we go to is the same, there're only five or six men against, excuse me, about up to 20 ladies" (male, YP)	(iii) Women are more social- "So if you look around the gym, there are quite a lot of individual men on machines doing individual exercises. When you look at a class, like our classes, it's dominated by women. I think they are more social" (male, NYP)
(vi) Men may be engaging in other activity- " or they join maybe more other things, you know, like walking or things like that" (male, NYP)	
(vii) Difficult to get men to pay attention to long term health issues- "Just as it's now recognized as a problem for example in the National Health Service, getting men to pay attention to their long term health, getting them to understand they shouldn't be over-weight, that it's not silly to have your blood pressure checked, and so on like that" (male, NYP)	
c. Society's view of yoga as a feminine activity is changing- "I think it's becoming more and more popular with men" (female, YP)	
d. Suggestions to encourage men to take up yoga-	
(i) Promote through football/rugby/swimming clubs and gyms- "If it was delivered through rugby club or football club or the swimming night" (female, YP)	
(ii) Role model for men- "You'd have to get a man to try to speak to them" (male, YP)	
(iii) Male only classes has been suggested by some, while most disagree- "I've often said to the instructor, why doesn't she have a class for our husbands?" (female, YP) "I don't want a male only class or a female only class and…I don' really want that. But it's nice if it's a mixed, sort of, class" (male, NYP)	
(iv) Male instructor has been suggested by some, while others disagree- "Finding a male teacher. They would be better with a male teacher" (female, YP) "I don't think it actually should matter at all, but I think in training people to take exercise classes, like our classes, whether you're a man or a woman" (male, NYP)	
(v) Promoting the benefits of the social aspect of yoga- "I think you need a soft entry into yoga. So that they have the initial social thing, getting a group together, and being able to see it as something pleasurable" (male, NYP)	
(vi) Adjust the class content so it's less contemplative, and less demanding of men- "not too demanding or expecting them to do things which are way beyond their capabilities" (male, NYP)	
(vii) Target younger men, as older one's may be set in their ways- "But if you want to say what can we do for men like us, it may be that we're beyond help" (male, NYP)	
3. Guidance for instructors	
a. Communication	

(i) Audible- "...and the teacher looks at the floor like that and speaks quietly and even when they ask the teacher to speak up, they're not capable, and it's so frustrating" (female, YP)	(i) Verbal correction and feedback rather than physically correcting postures- "And he came behind me, gave me a little push in the back. And actually, that day with my sore back was the wrong thing, and it actually hurt" (male, YP)
(ii) Clear instructions- "We're very lucky, the instructor is very precise and exact in what she wants us to do, so we aren't confused as to what she's asking us to do" (female, YP)	
(iii) Good communication style and not bark out instructions- "you know, like any instructor, to be good at speaking and everything and be able to converse, not just bark out instructions" (male, NYP)	
(iv) Demonstrates- "She will demonstrate what she wants you to do. Some teachers don't. They'll do it and you're supposed to watch them and do it at the same time and it's very difficult to actually do that" (female, YP)	
b. Creates an non-threatening and comfortable environment- "And doesn't force you into things that you don't feel able to do" (Female, NYP)	
c. Understanding older women and old age- "Understanding of the older women" (female, YP)	
d. Informed about each individual, asks about injuries, caring- "Always asks a new person if they've got any health problems or joint problems. So she's always very informed about each individual" (female, YP)	
e. Aware of class and level- "..so I think the teacher has to be aware of the class that she's taking and what level they're at.." (female, NYP)	
f. Offers alternative exercises- "Either say bringing in a chair if you don't want to go upside down. Or you know just doing an easier alternative way" (female, YP)	
g. Training and experience- "So I would expect the person to have training in what they're doing so that they know the different…I mean, not just knowing the moves and know what they do and everything and how often they do it or whatever…" (male, NYP)	
h. An inspiration- "She's an inspiration really" (female, YP)	
4. Strategies to promote yoga	
a. Providing more information around yoga- "that people need to know the benefits of yoga" (male, NYP)	a. Promoting contemplative side of yoga as a way to improve quality of life- "But yoga is there overtly to have a contemplative aspect as well as a physical. And maybe if it emphasized that little more" (male, NYP)
b. Taster sessions or introductory classes- "But I've not had the opportunity or seen anything, like, to go…as you said, like, for a taster session to see what it's all about" (male, NYP)	
c. A Promoting and incorporating some yoga in other exercise classes- "..say the class lasts about 45 minutes or 50, I'll just take 5 minutes and say, well this is the kind of thing we do at yoga. And then after you've	

done it if you say 5 minutes every week, you might say, well if you like or you benefitted from this, why not try the Wednesday morning" (male, NYP)	
d. A People who do it get others in- "well a friend was in a yoga class, and we started doing yoga together at lunch time from work" (male, YP)	
e. Promote medically and through GPs, physio recommendations- "I also think medically they could promote it some more" (female, YP)	
f. Promote yoga at retirement courses- "I was thinking of the general population with going out to the retirement courses and giving something to think about as to the benefits of it" (female, YP)	

Appendix 24. Knowledge Exchange event information poster

Yoga for an Older Adult Population

A workshop for teachers, researchers, and programme designers - a synergy of research and practice to share ideas and discuss aspects of developing and delivering yoga programmes for an older adult population.

Date: 24 October 2017
Time: 9.30 am – 1.30 pm
Venue: St. Leonard's Land (Room 3.24)
University of Edinburgh
Holyrood Road
Edinburgh, EH8 8AQ

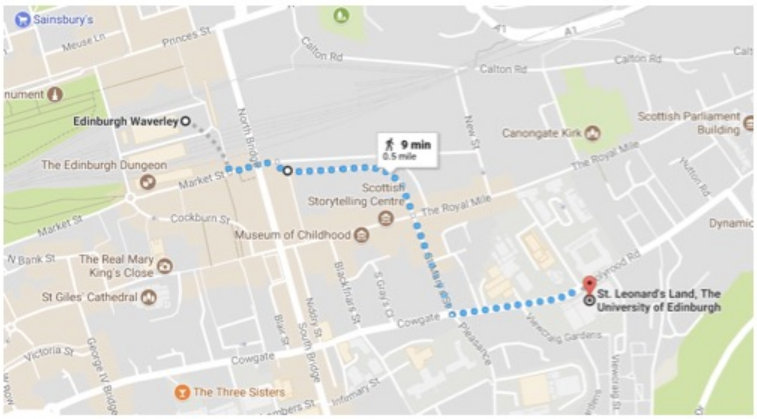
Registration is free, but places are limited. Free lunch included.

Please register at:
https://www.eventbrite.com/e/yoga-for-an-older-adult-population-tickets-37306992218

Contact: Divya Sivaramakrishnan
s1460453@sms.ed.ac.uk
0131 651 7112

THE UNIVERSITY of EDINBURGH | Physical Activity for Health Research Centre

Find us:
St. Leonard's Land (Room 3.24)
University of Edinburgh
Holyrood Road
Edinburgh, EH8 8AQ



Walking instructions from Edinburgh Waverley

Edinburgh Waverley
Edinburgh EH1 1BB

- Walk south towards Market St — 46 ft
- Turn left onto Market St — 253 ft
- Turn right onto Jeffrey St — 0.2 mi
- Continue onto St Mary's St — 0.1 mi
- Turn left onto Holyrood Rd — Destination will be on the right — 0.1 mi

St. Leonard's Land, The University of Edinburgh
Holyrood Road, Edinburgh EH8 8AQ

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Appendix 25. Knowledge exchange event report

THE UNIVERSITY of EDINBURGH | Physical Activity for Health Research Centre

Yoga for an Older Population
Knowledge Exchange Event

Photo credit: ymcapdx, Flickr

24 October 2017

Facilitators:
Divya Sivaramakrishnan
Dr. Claire Fitzsimons
Mary Alison

Physical Activity for Health Research Centre
Institute for Sport, Physical Education & Health Sciences
University of Edinburgh

Knowledge Exchange Event - Yoga for an Older Population

The knowledge exchange event held on 24th October 2017 was a great opportunity for people interested in yoga for an older age-group to come together and discuss common issues, share experiences and propose solutions to improve engagement and delivery of yoga classes for this population. The event was organised by Divya Sivaramakrishnan from the Physical Activity for Health Research Centre (University of Edinburgh), a third year PhD student who is currently working on this topic. Divya facilitated the event, along with Mary Alison and Dr. Claire Fitzsimons. Twenty-five participants from across Scotland attended the event. Participants included yoga teachers, studio owners and researchers. Josie Ford, a professional illustrator captured the event through live drawings.

The agenda for the event included activities for the participants, and presentation of research evidence. Participants commented on some key themes pertaining to yoga for older adults. They also discussed some of the dos and don'ts to be considered while designing a yoga intervention for this population. The discussions are summarised on page 2.

The research evidence presented included statistics on yoga participation and physical activity guidelines. Data from the Scottish Health Survey (2014)[1] shows that only 2% of adults in the 65-74 years age group, and 0% of adults over 75 years have participated in yoga (in the past 4 weeks). The physical activity recommendations[2] for the older adult population include aerobic, muscle strengthening, and balance and co-ordination guidelines (Figure 1). Yoga is recommended within the guidelines as a strength building activity.

Figure 1. Physical Activity recommendations for adults and older adults[2]

Some results from a qualitative study conducted as a part of the ongoing PhD project were also presented (Table 1).

Table 1. Findings from 19 participants from Edinburgh with and without prior yoga experience

Class duration	People with yoga experience preferred an hour and 15 minutes, and those who have never done yoga preferred less than an hour. Both groups were comfortable with one hour.
Class frequency	Once or twice per week was the preferred class frequency.
Name of class	It was suggested that the name can include "yoga" followed by a tag line or phrases that explain what it is or describe who it is for.
Pace of class	A gentle pace was preferred. Providing alternative poses and modifications was suggested, so people could take it at their own pace.

Contact: Divya Sivaramakrishnan. Physical Activity for Health Research Centre (PAHRC), University of Edinburgh, 2.23 St Leonard's Land, Holyrood Road, Edinburgh
Tel: 0131 651 4123 mail: s1460453@sms.ed.ac.uk

Comments from participants on themes pertaining to yoga for an older population

Perceptions of yoga: benefits and apprehensions

"..when I ask people about their intention for coming here, around 80% both men and women say they want to reduce stress...When I ask what held you back from coming before, it's I'm not flexible enough...So make it functional and show demonstrations.."

Gender

"Yoga is seen very often as a middle class, yummy mummy..because of the images that we see..so unless we can change that, have some guys with their gut hanging over, a bit like me, old, doing stuff, you know...positive role models"

Guidance for instructors

"..you have to use the insights of the older people around you to help you, so find somebody who's got a hearing difficulty in class and ask them what they need..and that'll give you some tips that will help other people with hearing difficulties.."

Strategies to promote yoga

"publicising the extensive health benefits of exercise, and also yoga for its capacity to stimulate brain growth and increase neural connections..that needs to be more widely publicised.."

Dos and Don'ts while designing an intervention

Some aspects from the event that participants felt they would implement were consideration of language, slowing down the pace of class, and including a social component. Participants also felt that the promotion of yoga for this age group should emphasise the positive effects of yoga like strength, balance, functional and cognitive benefits.

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Tel: 0131 651 4123 mail: s1460453@sms.ed.ac.uk

References

1. Gill, V. (2015). Chapter 5: Physical activity. In D. Campbell-Jack, S. Hinchliffe, & C. Bromley (Eds.), *The Scottish Health Survey 2014: Volume 1: Main Report*. Edinburgh: The Scottish Government.
2. Department of Health. (2011). *Start Active, Stay Active. A report on physical activity for health from the four home countries' Chief Medical Officers*. Retrieved from http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_128209

Contact details of participants

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Mr. Alexis Beddoe	Yoga teacher		beddoealexis@gmail.com
Ms. Joanna Cole-Hamilton	Yoga teacher		joannacolehamilton@gmail.com
Dr. Leonora Coll	Yoga/mindfulness teacher		colldrleo@hotmail.com
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Ms. Jennifer Reid	Teacher of Kundalini Yoga as taught by Yogi Bhajan	Kundalini Yoga Fife	jen.reid@mac.com
Ms. Divya Sivaramakrishnan	Yoga teacher / PhD student	University of Edinburgh	s1460453@sms.ed.ac.uk
Mr. Ian Stead	Yoga instructor	Self employed	stead12@hotmail.com

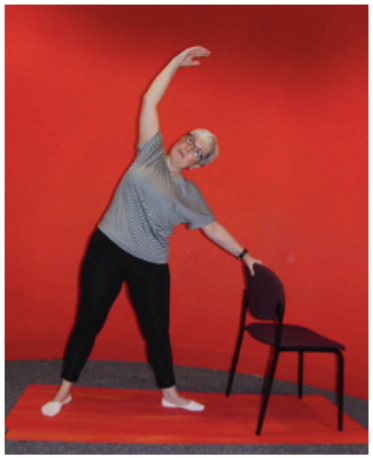
Appendix 26. Illustration of the 6 main postures from the yoga taster session exemplar

(i) One-foot balance

(ii) Warrior pose.

(iii) Chair pose

(iv) Triangle pose



(v) Cat-cow on chair

(vi) Downward dog on chair

Appendix 27. COREQ checklist for Study 3

COREQ (COnsolidated criteria for REporting Qualitative research) Checklist

A checklist of items that should be included in reports of qualitative research. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Topic	Item No.	Guide Questions/Description	Reported on Page No.
Domain 1: Research team and reflexivity			
Personal characteristics			
Interviewer/facilitator	1	Which author/s conducted the interview or focus group?	175
Credentials	2	What were the researcher's credentials? E.g. PhD, MD	vii
Occupation	3	What was their occupation at the time of the study?	vii
Gender	4	Was the researcher male or female?	113
Experience and training	5	What experience or training did the researcher have?	113
Relationship with participants			
Relationship established	6	Was a relationship established prior to study commencement?	168-170
Participant knowledge of the interviewer	7	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	168-170
Interviewer characteristics	8	What characteristics were reported about the inter viewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	vii
Domain 2: Study design			
Theoretical framework			
Methodological orientation and Theory	9	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	176, 179
Participant selection			
Sampling	10	How were participants selected? e.g. purposive, convenience, consecutive, snowball	168
Method of approach	11	How were participants approached? e.g. face-to-face, telephone, mail, email	168-170
Sample size	12	How many participants were in the study?	Table 14
Non-participation	13	How many people refused to participate or dropped out? Reasons?	169
Setting			
Setting of data collection	14	Where was the data collected? e.g. home, clinic, workplace	170
Presence of non-participants	15	Was anyone else present besides the participants and researchers?	170
Description of sample	16	What are the important characteristics of the sample? e.g. demographic data, date	Table 14
Data collection			
Interview guide	17	Were questions, prompts, guides provided by the authors? Was it pilot tested?	170-175
Repeat interviews	18	Were repeat inter views carried out? If yes, how many?	N/A
Audio/visual recording	19	Did the research use audio or visual recording to collect the data?	175
Field notes	20	Were field notes made during and/or after the inter view or focus group?	N/A
Duration	21	What was the duration of the inter views or focus group?	171
Data saturation	22	Was data saturation discussed?	314
Transcripts returned	23	Were transcripts returned to participants for comment and/or	113

Topic	Item No.	Guide Questions/Description	Reported on Page No.
		correction?	
Domain 3: analysis and findings			
Data analysis			
Number of data coders	24	How many data coders coded the data?	178
Description of the coding tree	25	Did authors provide a description of the coding tree?	Table 13
Derivation of themes	26	Were themes identified in advance or derived from the data?	178
Software	27	What software, if applicable, was used to manage the data?	179
Participant checking	28	Did participants provide feedback on the findings?	179, 180
Reporting			
Quotations presented	29	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number	181-206
Data and findings consistent	30	Was there consistency between the data presented and the findings?	181-206
Clarity of major themes	31	Were major themes clearly presented in the findings?	181-206
Clarity of minor themes	32	Is there a description of diverse cases or discussion of minor themes?	181-206

Developed from: Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. 2007. Volume 19, Number 6: pp. 349 – 357

Once you have completed this checklist, please save a copy and upload it as part of your submission. DO NOT include this checklist as part of the main manuscript document. It must be uploaded as a separate file.

Note: The responses to some items may be reported in different sections of the thesis. To avoid repetition, they may not have been reported again in Chapter 4 (Study 3)

Appendix 28. Recruitment poster for Study 3

Free yoga class for those over 65 years

Contact:

Divya Sivaramakrishnan
S1460453@sms.ed.ac.uk
0131 651 4123

Inclusion criteria

- Age: 65 years and over
- Haven't attended a regular yoga class before
- Able to walk without assistance

Date, time and venue

Date: 26 April 2018

Time: 10-12 am

Venue: Thomson's Land, Holyrood road, Edinburgh

We would like your help with a research study we are running in the Physical Activity for Health Research Centre.

What do I have to do?

- Come along to a FREE 30-minute yoga class.
- Tell us what you thought of the class and a promotional leaflet.
- Try out a couple of yoga exercises at home and tell us what you think.

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Appendix 29. Study 3 risk assessment form

General Risk Assessment

Form RA1

(Refer to Notes for Guidance before completing this form)

School Assessment No:	
Title of Activity:	Research study evaluating components of a yoga programme
Location(s) of Work:	1. St. Leonard's Land, University of Edinburgh 2. Centre for Sport and Exercise (University of Edinburgh) 3. Edinburgh Leisure Centres

Brief Description of Work:

For this study, we aim to procure feedback on some components of a yoga intervention for adults aged 65 years and over in Scotland. These include conducting yoga taster sessions, using leaflets to promote yoga, and providing a home-based yoga handout for participants to do the exercises at home for a week. We will be conducting 2-4 yoga taster sessions, each for 30-minutes, conducted by an experienced yoga teacher. Each session will have 2-8 participants. The home-based handout will have poses from the session, so that participants have already done the poses under the guidance of a yoga instructor. Study inclusion criteria:

- Male and female participants
- 65 years and over
- Never participated in yoga
- Able to walk without assistance
- Able to give informed consent and follow study instructions

This risk assessment is being undertaken for the yoga taster sessions and home-based exercises.

Hazard Identification: Identify all the hazards; evaluate the risks (low / medium / high); describe all existing control measures and identify any further measures required. Specific hazards should be assessed on a separate risk assessment form and cross-referenced with this document. Specific assessments are available for hazardous substances, biological agents, display screen equipment, manual handling operations and fieldwork. See http://www.ed.ac.uk/schools-departments/health-safety/risk-assessments-checklists/risk-assessments for details.

Hazard(s)	**Present Risk Evaluation** L/M/H	**Control Measures** (i.e., alternative work methods / mechanical aids / engineering controls, etc.)	**Risk Evaluation after control** L/M/H
Falls and minor injuries during taster session	M	The session has been designed for older adults. It will be conducted at a gentle pace, and the aerobic intensity would be light. The instructor will ask about injuries before the session starts, and also tell the participants to take it at their own pace and that they should not force themselves to perform any of the postures. Props like chairs will be used, and modifications to postures will be suggested if required. Participants will be informed (participant information sheet) that should they have any uncertainties or reservations about their ability to participate, they should consult their doctor. Despite this, there is a small chance of falls or minor injuries like a sprain, or muscle pull. We will ensure that first aid is on hand in case of any adverse events. Following the class participants may experience some mild muscular discomfort. Participants will be informed this is normal and if they experience any discomfort beyond a mild level they should seek medical advice.	L
Falls and minor injuries during the home-based activity	M	Participants will be given a home-based handout and requested to do the postures on 2 days for a week after the taster sessions. Since the exercises in the handouts have already been done during the taster	L

		session, participants are familiar with them. The aerobic intensity would be light. We will ask the participants to make sure that they have first aid/emergency numbers readily available in case of any adverse events. This will be mentioned in the participant information sheet and the instructor will also brief all participants on this.	

**Continue on separate sheet if necessary*

Engineering Controls: *Tick relevant boxes*

Guarding		Extraction (LEV)		Interlocks		Enclosure	
Other relevant information (incl. testing frequency if appropriate):							

Personal Protective Equipment (PPE): Identify all necessary PPE.

Eye / Face		Hand /Arm		Feet / Legs		Respiratory	
Body (clothing)		Hearing		Other (Specify)			
Specify the grade(s) of PPE to be worn:							
Specify when during the activity the item(s) of PPE must be worn:							

Non-disposable items of PPE must be inspected regularly and records retained for inspection

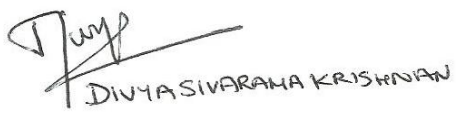
Persons at Risk: Identify all those who may be at risk.

Academic staff		Technical staff		P'Grad students		U'Grad students	
Maintenance staff		Office staff		Cleaning staff		Emergency personnel	
Contractors		Visitors		Others	✓		

Additional Information: Identify any additional information relevant to the activity, including supervision, training requirements, special emergency procedures, requirement for health surveillance etc.

The locations where we are planning to have the taster sessions (St. Leonard's Land (University of Edinburgh), Centre for Sport and Exercise (University of Edinburgh), Edinburgh Leisure Centres) are venues where physical activity regularly takes place and have first aid procedures in place.

Assessment carried out by:

Name:	Divya Sivaramakrishnan	Date:	27 Jan 2018
Signature:		Review Date:	

Appendix 30. Study 3 participant information sheet

Evaluating Yoga Programme Components in Older Adults

Participant Information Sheet

You are invited to take part in a research study undertaken by the Physical Activity for Health Research Centre at the University of Edinburgh. Before you decide whether or not to take part, it is important that you understand why the research is being done, and what it will involve.

What is the purpose of the study?

We are in the process of designing a yoga programme for older people and would like to understand how you feel about some elements of the programme. We would like your feedback on a leaflet about yoga, and a short yoga taster session. We will use your feedback to produce a yoga programme that is suitable and appealing to adults over 65 years.

Why have I been invited?

You are invited to participate in this research study if you satisfy the following inclusion criteria:

- Age: 65 years and over
- Haven't participated in a regular yoga class before
- Able to walk at least 10 metres without assistance from anyone else
- Able to give informed consent and follow study instruction

Do I have to take part?

No it is up to you to decide. You can take your time to read the information, ask questions, and talk to your friends/family to help you decide. Even if you decide to take part, you can withdraw from the study at any time, without giving a reason. If you feel uncertain or have

reservations about your ability to take part, please consult your doctor before participating.

What will happen if I take part?

Once you have decided to take part, you will be invited to attend a yoga taster session. The taster session will be conducted at a date, time and location convenient for you, and you will be participating along with other individuals in the same age group. The session will last for around 30 minutes, and will involve yoga postures and breathing exercises. The session will be conducted at a gentle pace, and you can go at your own pace. People of all abilities can take part.


Sample yoga classes

After this there will be an evaluation session to collect your feedback. You will be requested to fill in a simple questionnaire and participate in a group discussion. You will also be requested to share your thoughts and comments on a leaflet on yoga. The evaluation session will take approximately 90 minutes, and tea, coffee and biscuits will be provided. Finally, you'll be given a home-based exercise handout, and requested to perform the exercises at home in the following week on at least two days. Please have a first aid or emergency number readily available while performing the exercises at home in case of a fall or injury. The researcher will conduct a phone interview with you at the end of the week lasting for

approximately 15 minutes to get your feedback on the home-based exercises. The group discussions and interviews will be audio recorded.

What are the possible benefits of taking part?

You will be able to try out a yoga class at no cost. You will also receive a yoga leaflet and a home-based exercise handout. Your feedback and comments will feed into the development of a yoga programme that is appealing and appropriate for older adults.

What are the possible disadvantages and risks of taking part?

This is a low risk study. The yoga programme has been designed specifically with over 65s in mind, using props like chairs if required. The session will be delivered by an experienced yoga teacher. First aid procedures are in place for this study.

What will happen to the information that I provide?

We will carry out this study in accordance with good practice guidelines regarding participant confidentiality and data protection. Data from audio recordings and written transcripts will be stored securely at the University of Edinburgh. Only researchers involved in this study will be able to access them. When we publish the findings of this research we may quote from your questionnaire, group discussion, or interview, but if we do this it will be in such a way that your identity is safe. At the end of the project, transcripts with individual identifiers removed may be made available for other researchers to use.

What will happen to the results of the study?

The information collected and quotes from the discussion and interviews will be included in a PhD thesis, published in research papers and presented in scientific conferences and seminars.

What if there is a problem?

During the study please contact a member of the research team if you have any questions.

- You can contact Divya Sivaramakrishnan on +44 (0)131 651 4123 or email: s1460453@sms.ed.ac.uk
- You can contact Dr. Claire Fitzsimons on +44 (0)131 651 6049 or email: claire.fitzsimons@ed.ac.uk

If you wish to complain, or have any concerns about any aspect of the way you have been approached or treated during the course of this study, please contact Prof. Nanette Mutrie (Director of the Physical Activity for Health Research Centre, PAHRC), University of Edinburgh on +44 (0)131 651 6532 or email: nanette.mutrie@ed.ac.uk.

What happens next?

If you would like to participate in this study, please read and sign the consent form and bring it along to the taster session. A researcher will be in touch with you to coordinate a convenient date and location for the taster session. You will be taking part in this session with some other individuals, and the date, time and location will be decided based on everyone's convenience. You will be notified once the date and venue are finalised. Let us know if you would like us to remind you on the day before the session, and we would be happy to give you a reminder call. After this you just have to come to the session on the day and time specified.

Thank you very much for taking the time to read this information.

For more information, or if you have any questions, please contact:

Divya Sivaramakrishnan, 2.23 St Leonard's Land, Holyrood road, Edinburgh EH8 8AQ, email: S1460453@sms.ed.ac.uk, Tel: +44 (0)131 651 4123

Appendix 31. Ethics approval letter for Study 3

THE UNIVERSITY of EDINBURGH
Moray House School of Education

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Moray House School of Education
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Edinburgh EH8 8AQ

D/D +44 (0)131 651 6388
S/B +44 (0)131 650 1000

www.ed.ac.uk

Divya Sivaramakrishnan
SPEHS
St Leonards Land

6 March 2018

Our Ref: 1243

Dear Divya

Title: Evaluating yoga programme components for older adults

The School of Education Ethics Sub-Committee has now considered your request for ethical approval for the studies detailed in your application.

This is to confirm that the Sub-Committee is happy to approve the application and that the research meets the School Ethics Level 2 criterion. This is defined as "applies to non-intervention research where you have the consent of the participants and data subjects. This may include, for example, analysis of archived data, classroom observation, or questionnaires on topics that are not generally considered 'sensitive'. This research can involve children or young people, if the likelihood of risk to them is minimal".

A standard condition of this ethical approval is that you are required to notify the Committee, of any significant proposed deviation from the original protocol. The Committee also needs to be notified if there are any unexpected results or events once the research is underway that raise questions about the safety of the research.

Should you receive any formal complaints relating to the study you should notify the MHSE Ethics Committee immediately by email to Shona Cunningham at s.cunningham@ed.ac.uk.

Yours sincerely

S Cunningham

Dr Ailsa Niven
Convener, School Ethics Sub-Committee

Appendix 32. Study 3 consent form

Evaluating Yoga Programme Components in Older Adults
Participant Consent Form

	Please read the following statements and initial the box in response	Please initial box
1	I confirm that I have read and understand the information sheet for the above study (Evaluating yoga programme components in older adults). I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	☐
2	I understand that participation is voluntary and that I am free to withdraw at any time, without giving any reason and without any consequences.	☐
3	I understand that I will be participating in a yoga taster session followed by an evaluation session.	☐
4	I understand that I will be performing some home-based exercises and providing feedback on this through a phone interview.	☐
5	I understand that I will be participating in the taster sessions and performing home-based exercises at my own risk.	☐
6	I understand that the group discussion and interviews will be audio-recorded and transcribed.	☐

7	I understand and agree that the data collected including quotes will be used for a research thesis, and will be published in scientific literature and presented at scientific conferences. I understand that all data will be anonymised.	☐
8	I agree to take part in this study.	☐
9	I understand that personal information collected will be stored securely on University of Edinburgh premises.	☐
10	I understand that the information collected about me will be stored in a confidential and anonymous electronic database, which may be used to support other research in future, and may be shared anonymously with other researchers.	☐
11	I consent to future contact regarding possible participation in further research arising directly from this study. I understand that this will not commit me to taking part in further research.	☐

_____	_____	_____
Name of Participant	Date	Signature

_____	_____	_____
Name of person taking consent	Date	Signature

Appendix 33. Study 3 taster session/leaflet focus group guide and home-based interview schedule

Study 3 topic guide- Focus group discussion to collect feedback on taster sessions and leaflets

1. Thank you very much for attending the session today. I hope you enjoyed the yoga session. I would now like to ask you for your feedback on the session and a yoga leaflet that will be shown to you. Your comments will help us improve the material, so please do not hesitate to give us honest feedback even if it is negative.

2. Introduce myself and co-moderator.

3. Just a few points to mention:
    - You do the talking, and we would like everyone to participate in the discussion.
    - No right and wrong answers.
    - We will be audio recording the discussion. What you say will be confidential and stays in this room. We won't identify anyone by name in our report.
    - You are free to leave at any time with no consequences.

Sno	Theme	Questions	Prompts
1	**Feedback on the taster session**		
1.1	General feedback	Let's start with how you felt about the session. Any feedback on the session?	1. Did you feel ok after the session? 2. What didn't you like about the session? 3. Any suggestions on how these can be addressed?
1.2	Movement between standing up and floor	There were some standing poses, and some sitting and lying down poses in the session. How did you find the movement between postures?	
1.3	Lack of aerobic element	Do you think that yoga can be beneficial?	1. After doing the session, what are some of the benefits you think yoga could have?
1.4	Comments on the breathing/meditation section	What did you feel about the breathing and meditation you did towards the end of the class?	1. What did you feel about the duration/length of the breathing and meditation aspect?
1.5	Comments on the instructor	Do you have any feedback on the teaching style?	1. What did you like about the instructor? 2. Is there anything the instructor could have done to make you feel more comfortable and relaxed?
1.6	Any final comments on the session?	Any other comments or suggestions on the session you just attended?	1. Any suggestions on how it can be improved?
2	**Feedback on the leaflets**		
2.1	General feedback	What did you think of the leaflet? Did you find it useful?	

2.2	Design	What did you feel about the design and layout of the leaflet? How do you like the colours?	1. Is the font size ok?
2.3	Content	Do you have any comments on the information provided in the leaflet?	1. What did you learn about yoga after reading the leaflets? 2. Do you feel you have more information on the benefits of yoga after reading the leaflet? 3. What did you think about the amount of information on the leaflet? Too much/too little?
2.4	Language	What did you feel about the wording	1. Any words or phrases you liked? 2. Any words or phrases you didn't like?
2.5	Pictures	Do you feel the pictures would be appealing to the 65+ age-group?	
2.6	Motivation	Do you think the leaflet would motivate you to attend a yoga class?	1. What about the leaflet would motivate you? 2. Why not?
2.7	Any final comments on the leaflet?	Any other comments or suggestions with respect to the leaflet?	1. Any suggestions on how it can be improved?

Note on homebased exercises for participants (after the taster session): You have just received a home-based handout which contains postures that you just did at the taster session. Would you be able to do the exercises on at least 2 days a week, for the next week? We will call you after a week to see how you got on.

Do you have any questions regarding the exercises?

Interview guide for homebased exercises. Phone based interviews to be conducted 1 week after the taster sessions

Sno	Theme	Questions	Prompts
1	**Home-based exercises**		
1.1	Adherence	Were you able to do the exercises in the handout?	
		If no- why were you not able to do the exercises at home? What can we do to help you do the home exercises?	
		If yes- how many times did you do the exercises last week? How long did each session take?	1. Were you comfortable with the duration of the session?
1.2	Handout	Was the handout easy to follow?	1. Is there anything you did not like about the handout? 2. Any suggestions to improve the handout?
1.3	Exercises	Were the exercises easy to do by yourself? What did you feel about the breathing aspect?	1. Was it helpful that you've done the postures before in the taster session?
	Feasibility of home-based exercises	If you were given handouts containing postures you have done in class under the guidance of an instructor, do you think you would do the exercises at home regularly at least once a week?	
	Handouts vs other methods	Do you think you would prefer some other material or method such as videos to help you with your home-based exercises.	
1.4	Injuries	Did you have any injuries or experience any discomfort when doing the postures at home?	
1.5	Any final comments	Do you have any other comments on the homebased exercises?	
Thank you so much for your feedback. We hope you will continue to do the exercises.			

Appendix 34. Study 3 taster session questionnaire

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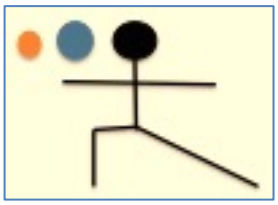

Yoga Study PAHRC

Evaluation Questionnaire

Thank you for attending the session. Please complete the attached evaluation questionnaire.

YOUR DETAILS

Name: _____
_

Age: _____

Sex: [1] Male

[2] Female

Participant ID (to be filled in by researcher):

Participant ID (to be filled in by researcher):

Please tick the appropriate box.

1. We would like to understand if you enjoyed the session. Choose the most appropriate option.

   I enjoyed the yoga taster session.

   1. Strongly disagree ☐
   2. Disagree ☐
   3. Neutral ☐
   4. Agree ☐
   5. Strongly agree ☐

   Please comment on why you chose your answer.

2. We would like to understand whether you experienced any feelings of embarrassment during the session. Choose the most appropriate option.

   I felt embarrassed during the yoga taster session.

   1. Strongly disagree ☐
   2. Disagree ☐
   3. Neutral ☐
   4. Agree ☐
   5. Strongly agree ☐

Please comment on why you chose your answer.

3. We would like to understand if you found the session difficult. Choose the most appropriate option.

   I found the session difficult.

   1. Strongly disagree ☐
   2. Disagree ☐
   3. Neutral ☐
   4. Agree ☐
   5. Strongly agree ☐

   Please comment on why you chose your answer.

4. Do you think that you're likely to participate in future yoga sessions? Choose the most appropriate option.

   I am likely to participate in yoga sessions in the future.

   1. Strongly disagree ☐
   2. Disagree ☐
   3. Neutral ☐
   4. Agree ☐
   5. Strongly agree ☐

   Please comment on why you chose your answer.

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS QUESTIONNAIRE!

Appendix 35. Brief for instructor in Study 3

Background

The objective of this PhD project is to develop an appealing, appropriate and acceptable yoga program for older adults in Scotland. Study 1 of the PhD is a systematic review establishing the effects of yoga in older adults. Study 2 is a qualitative study, exploring the perceptions of yoga in older adults. Findings from study 2 included understanding the apprehensions that older adults with no yoga experience may have with respect to yoga participation, guidance for instructors and strategies to promote yoga in the older adult age-group. In addition, a knowledge exchange event was conducted in October 2017, with yoga teachers, studio owners and researchers, where some of these findings were validated and new insights compiled. For the third study, we will test some of these identified components that aim to overcome the barriers to participating in yoga, and help create an appealing, acceptable and appropriate yoga programme. The third study consists of 3 main elements-

(i) Promoting yoga to older adults using leaflets

(ii) Conducting yoga taster sessions

(iii) Using home-based yoga handouts to encourage home-based practice

A summary of study 1 and 2 are provided below, and the report from the KE event is attached.

Systematic review summary

A systematic review was conducted to assess the effectiveness of yoga in improving physical function and quality of life in healthy older adults. Yoga was found to improve balance, lower body flexibility, lower limb strength and mobility. With respect to quality of life measures, yoga improved depression, perceived mental health, perceived physical health and sleep. Yoga has been recommended in the Chief Medical Officers' report as a muscle strengthening activity (infographic attached), and the results of the systematic review support this recommendation. We should continue to prescribe yoga for older adults as an activity that improves physical function and mental health.

Perceptions of yoga in older adults summary

The aim of this study was to:

1. Explore the perceptions of yoga in adults over 65 years who have done yoga

before and never done yoga before

2. Understand why yoga is a female dominated activity
3. Provide guidance for yoga instructors
4. Provide strategies for promoting yoga in the older adult population

The findings from the study has been summarized in figure below (figure 1).

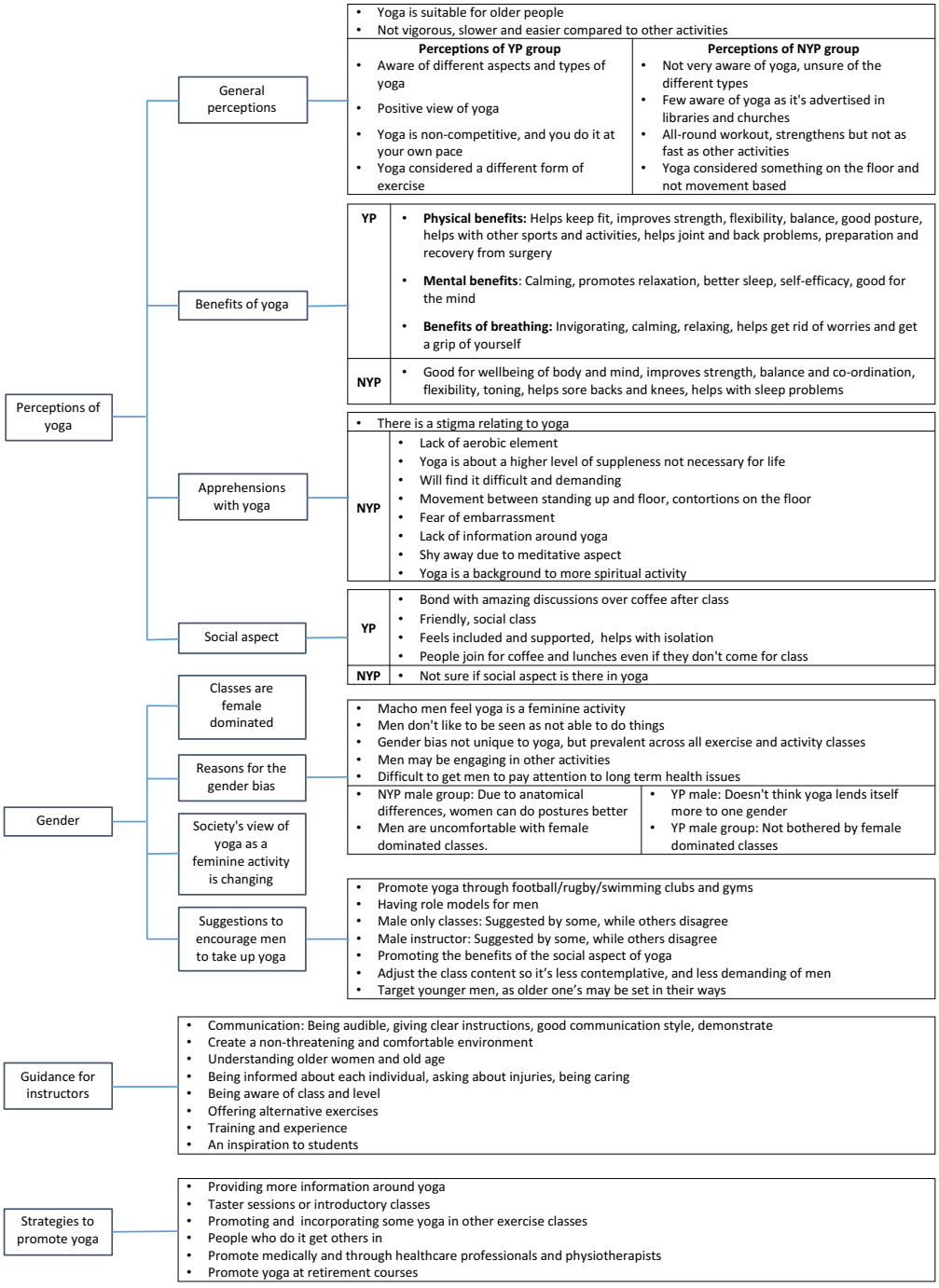

Figure 1: summary of findings from study

In this study (study 3), we will be testing out some aspects identified in study 2, which will feed into developing an appealing, acceptable and appropriate yoga intervention for older adults. Some perceptions and apprehensions identified in

study 2 include:

- Older adults felt that they will find yoga difficult and demanding
- Apprehensions about continuous movement between standing and floor
- Fear of embarrassment in a yoga class
- Lack of information on yoga
- Apprehensions about meditative/spiritual aspect
- Apprehensions regarding lack of aerobic element
- Pictures in books and handouts are usually of young and supple models

Elements relating to home-based exercises

- Older adults felt that they may do damage at home without a teacher
- No time/may do a shorter session
- Older adults may be more confident doing postures at home that have already been done in class under the guidance of a teacher.
- Pictures in handouts are usually of young people

The leaflets, taster sessions and homebased elements of this study address these aspects. While the full protocol for the study is attached, some details of the taster session are described below.

Taster session details

We will conduct 2-4 taster sessions in collaboration with Edinburgh Leisure and Centre for Sport and Exercise, University of Edinburgh (UOE). The number of taster sessions to be conducted was decided keeping in mind time and resource constraints.

1. Participants:
   (i) Inclusion criteria:
      - Male and female participants
      - 65 years and over
      - Haven't participated in a regular yoga class before
      - Able to walk at least 10 metres without assistance from anyone else
      - Able to give informed consent and follow study instructions

Note: participants will be advised that if they are uncertain or have reservations about their ability to participate in the yoga taster session, they should consult their doctor before participating. This will be mentioned in the participant information sheet.

(ii) Number of participants and sessions: 2-4 taster sessions will be conducted. Each session will have a minimum of 2 and a maximum of 8 participants

2. Recruitment of participants: We will employ a multi-level recruitment strategy. Some recruitment options are mentioned below. We will simultaneously explore all recruitment options.
   a. Edinburgh Leisure
   b. Sport and Exercise Centre, Pleasance, University of Edinburgh
   c. University of Edinburgh: Posters with information on the taster session will be put up around the university, and an email will be sent out to all UOE staff members.
   d. Snowballing and other recruitment options: Participants contacted can spread the word, and bring in other interested members. Word of mouth, and contacting other venues and organisations (such as Paths For All and fitness studios) are other recruitment options. We will also get in touch with participants of the previous qualitative study if they have given consent to future contact.

3. Location: The venue for the taster sessions will depend on participant's convenience. Venue options are as follows-
   a. Edinburgh Leisure centres
   b. Centre for Sport and Exercise, University of Edinburgh
   c. Gym/studio at St. Leonards Land, University of Edinburgh

4. Taster session features:
   - The session will be conducted at a gentle pace.
   - Props like chairs will be used.
   - Continuous movement between sitting/lying down and standing up, and complicated movements will be avoided.

- The sessions will include some breathing and meditation, but not too much.
- The duration of the yoga taster sessions will be approximately 30 minutes.

5. Guidance for the instructor: At the start of the taster session, the instructor should ask the participants if they have any injuries or conditions, and suggest appropriate modifications to postures.
   It is essential that the instructor makes it clear that participants can choose their own pace, avoid poses that they don't find comfortable and don't force themselves to perform the poses during the session.

6. Taster session structure: The postures for the taster session have been compiled from studies included in the systematic review. In addition to the detailed structure provided below, an illustration of poses used in one of the studies (Tew et al. 2017) is also provided (Figure 2)
   Warm up:
   (i) Coordinated breath and hand movement: stretch forward, and stretch hands up (marked as 1 in figure 2)
   (ii) Seated on chair: rotations- neck, shoulder, wrist, ankles
   (iii) Seated on chair: forward bend with one leg stretched out (marked as 2 in figure 2). Please note that this posture is in the home-based exercise handout.
   (iv) Standing up warm up movements: side stretches, hip rotation, standing spinal twist
   Postures:
   (i) One-foot balance (marked as 3 in figure 2). Please note that this posture is in the home-based handout.
   (ii) Warrior pose. Please note that this posture is in the home-based handout.
   (iii) Chair pose (marked as 4 in figure 2)
   (iv) Triangle pose
   (v) Cat-cow on chair (marked as 5 in figure 2).
   (vi) Downward dog on chair (marked as 6 in figure 2).
   Cool down (note- all reclining postures can be performed seated on a chair):

(i) Reclining one knee to chest

(ii) Reclining spinal twist

(iii) Reclining leg on wall

(iv) Corpse pose

Breathing

(i) Abdominal/ diaphragmatic breaths. Please note that this breathing exercise is in the home-based handout.

(ii) Muscle relaxation in corpse pose

7. Home-based exercises

The participants will be requested to practice yoga at home on at least two days in the week following the taster session, using a home-based handout. The home-based exercise handout The home-based handout will be provided to the instructor. Since, the handout contains pictures of poses already done in class, the instructor should ensure that these are covered in the class.

Figure 2. Sample exercises from Tew et al. (2017)

8. Evaluation

After the 30-minute taster session, participants will attend a focus group session where they will provide feedback on the session attended. Please note that this is not intended to assess instructor performance, but to understand if the session addressed the barriers identified, so that the yoga

program can be further refined. The focus groups will also provide feedback on the leaflets.

Feedback from the participants on the home-based exercises will be collected via a phone interview a week after the taster session.

A brief interview will also be conducted with the instructor who conducts the taster sessions to procure feedback on the experience of conducting the session, and on the brief provided to them.

Next steps for the instructor

The instructor is requested to get familiar with the study protocol and the taster session details, and get in touch with Divya Sivaramakrishnan if they have any questions or require more information. The instructor is also requested to forward or present a copy of yoga related certificates to Divya Sivaramakrishnan. The recruitment of participants for the will start in March 2018. Once interested participants provide possible dates for the taster session, the instructor will be contacted to check availability.

The following documents have been attached:

- Study protocol
- Knowledge exchange report
- Leaflet/home-based handout
- Physical activity recommendations for adults and older adults-infographic

For any questions or clarifications please contact

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Appendix 36. Study 3 Interview guide- capturing feedback from the instructor

1. Thank you very much for conducting the yoga taster sessions. I would now like to ask you for your feedback on the training material provided, and the delivery of the sessions. Your comments will help us improve the material, so please do not hesitate to give us honest feedback.
2. Just a few points to mention:
    - There are no right and wrong answers. Your feedback would be very useful for intervention development.
    - We will be audio recording the discussion. We would like to acknowledge your help with this project, and in this case, all quotes and feedback would be credited to you. However, you can remain anonymous if you prefer.
    - You are free to leave at any time with no consequences

Sno	Theme	Questions	Prompts
1.1	Overall feedback	You have conducted 4 taster sessions. Let's start with any overarching feedback you have on your experience with conducting these sessions.	
1.2	Training	What did you feel about the brief, and material made available to you before you conducted the session?	
1.3	Delivery	Do you have any comments on your experience with delivering the session?	1. Were you comfortable with the participants? 2. Was any aspect of the delivery challenging? 3. Were you able to accommodate participants of all fitness levels and abilities?
1.4	New postures and modifications	Did you do any postures other than those mentioned in the protocol? What were they? What are some of the posture modifications you introduced?	

1.5	Adverse event	Were there any injuries during any of the sessions?	
1.6	Suggestions for improvement	Do you have any suggestions to improve the sessions?	1. Any suggestions relating to class content, structure or guidance for instructors?

Appendix 37. Evaluation of taster sessions, leaflet, and home-based sessions and handouts as appealing, appropriate and acceptable

Programme component	Taster	Leaflet	Home-based exercises
Appealing			
Enjoyment, likes and dislikes	Enjoyed the session: In the questionnaire, 88% agreed or strongly agreed that they enjoyed the taster session. Participants expressed in the FG that they "enjoyed it", was "good" or "great". Didn't enjoy the session: Two participants felt that yoga was too slow and static and preferred other forms of exercise	Overall, the leaflet received very positive feedback with comments like “very nicely put together”, “not too patronising or over simplified”, “seems very good”. It was felt that the leaflet provided useful information and explanations.	Most participants had positive feedback on the home-based sessions, and expressed that they enjoyed doing the exercises at home. One participant found it a bit easy and too tame. However, participants felt that it is difficult to be regular with home-based practice and expressed a preference for class-based sessions. The main reason was that they felt more motivated, disciplined and focused in a class.
Creating a non-threatening environment and reducing feelings of embarrassment	94% of participants recorded in the questionnaire that they disagreed or strongly disagreed with the statement "I felt embarrassed during the yoga taster session" They also mentioned that they were made to feel that they could do the exercises, and that the instructor put them at ease. They felt that the instructor recognized that older adults may have aches and pains, may have issues such as shoulder trouble, and may not move very well. They appreciated that he asked if they were feeling alright or if they needed help.	Participants appreciated that the leaflet conveyed that yoga was for everyone, and that you could do it to whatever extent suits you.	

Design, layout, language in the leaflet		The participants commented that the leaflet was colourful and eye catching. The found the fount size easy to read. With respect to the size, they felt it may not fit into a handbag, and may be bulky to take away. A foldable booklet was suggested. Participants felt that the leaflet used a variety of appropriate and positive words like “have more energy” or “enjoy better sleep”. The language used was simple with no jargon.	
Pictures		Participants felt that good, realistic pictures were used in the leaflet. It featured people they could identify with. They also found that the pictures were reassuring and not too challenging, as the people were not doing contortions on the floor. The found having a chair in the pictures reassuring. Including pictures of men was suggested.	The pictures enhanced ease of understanding directions, and participants described them as useful helpful and clear.
Appropriate			
Serious adverse events	No serious adverse events reported		No serious adverse events reported

Injuries or discomfort	Participants indicated that they felt good after the class, with no discomfort. Two female participants experienced knee pain during the taster session, but the session did not worsen the pain.		Most participants experienced no injuries or discomfort during home-based practice. One participant had a badly arthritic knee and experienced some pain, specifically in the warrior pose. One participant felt some discomfort in the hamstring stretch in pose 1, but this could be attributed to limited hamstring flexibility.
Posture modifications	While the brief for instructors suggested posture modifications, more detail and training on the appropriate modifications for some key problem areas and health conditions (example: knees, difficulties in reclining) in older adults is required.		
Yoga is beneficial	Benefits experienced by participants- Participants felt relaxed and stretched after the session. Whole body was covered in the exercises, and they felt they were using multiple muscles such as abdominal and thighs during the session. They also felt that yoga would improve balance, posture, mobility/movement (benefit to shoulders), suppleness and flexibility. Helping with breathing properly and relaxing was seen as a major benefit.		Participants felt that the home-based sessions helped with limbering or loosening up. Another benefit was that the exercises helped them relax. They felt that the exercises were beneficial for their stomach muscles. Better posture and improved strength and balance were also mentioned.
Acceptable			

Able to do and difficulty levels	The majority of participants (65%) did not find the session difficult. Participants felt that the session was gentle and they could complete it with ease. Participants had anticipated finding the session more difficult, and were surprised they could do it. Suitable for older people, geared for them, within their capacity. Found some of it difficult due to age and unusual exercises. Participants felt the session was challenging but exercises the body		All participants except one were able to do the exercises at home. One participant did not do the exercises due to health reasons. Participants found the home-based sessions easy to do by themselves. One participant who did the exercises just once felt that they were not demanding enough.
Apprehensions about movement between sitting, standing and lying down	The participants thought that grouping sitting, standing and lying down postures together to minimise movement between getting down and up worked well. They felt that they would be quite tense if there was a lot of up and down movement. Knowing that you didn't have to get up and down each time made it more relaxing for them		

Breathing, meditative/spiritual aspect	Participants enjoyed the breathing and relaxation aspect and found it helpful and valuable. They felt it was a lovely way to end the session and found it very relaxing. Participants felt the duration of the breathing component was just right. Optimal spiritual content: they felt that the session was practical with no odd gestures. Participants found that breathing during postures is confusing, and sometimes they tend to hold the breath in.		The feedback on the breathing exercise was mixed. Some participants found it boring. They did not find it very helpful, did not think it would be beneficial, and questioned why it was there at all. They would have preferred more of the physical exercise. Others thought it was good, and that it helped oxygenate the body. They felt it may help with asthma as well as the muscles at the bottom of the stomach. Apart from the breathing exercise, participants found breathing during the postures complicated- they often forgot to breathe and held their breath in.
Duration	Most were happy with the duration of the taster session.		Participants had no difficulty with the length of time, and could manage it without being exhausted. Participants were also comfortable with the length of the session in terms of fitting it into their daily routine.
Structure and flow	Participants thought that the structure of the session was good, and progressed logically from one exercise to the next.		Participants had some questions on the order and repetitions, and when to do the breathing.

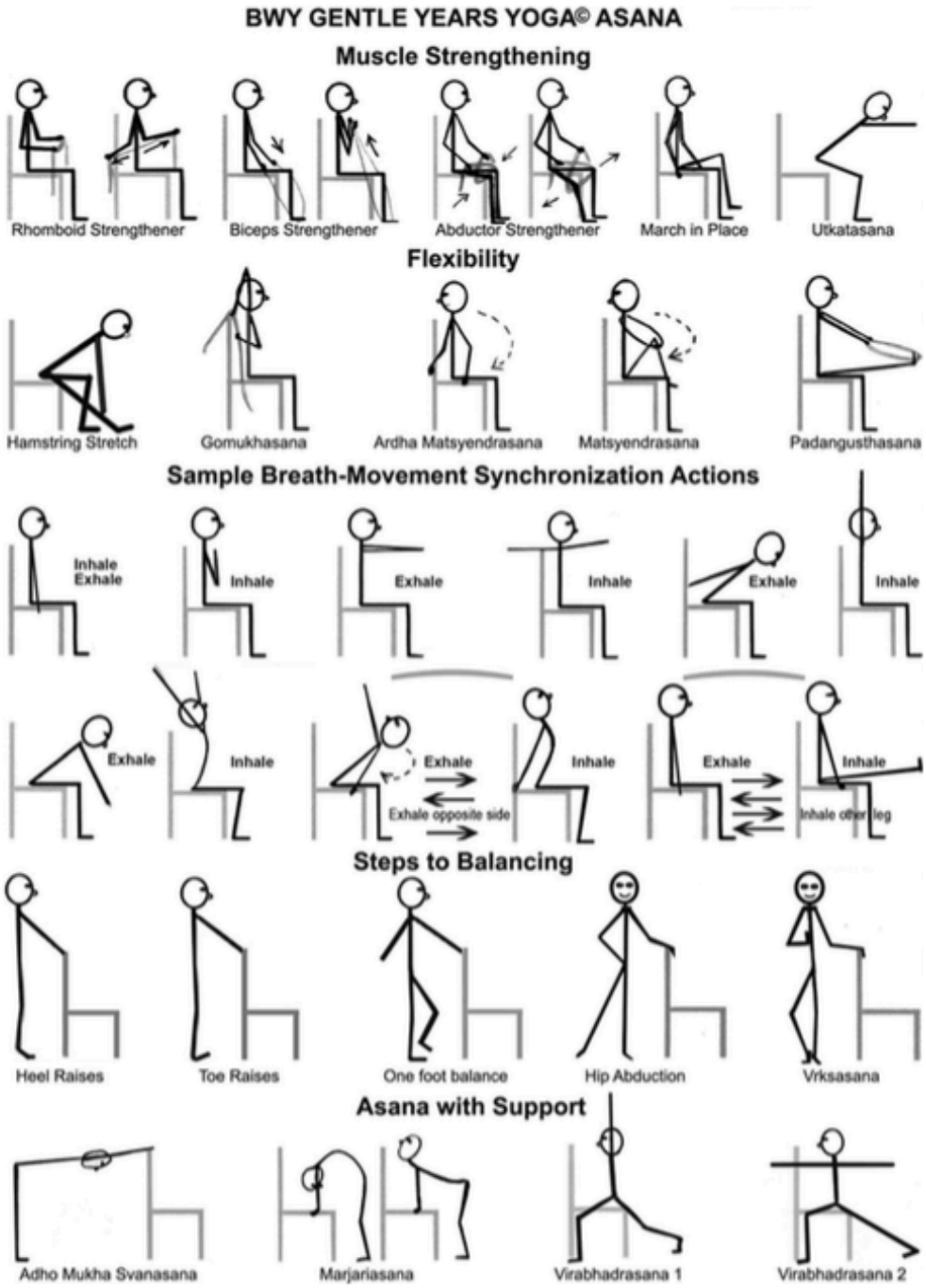
Class size and age group	Participants appreciated the advantages of a smaller class. Participants in one particular session mentioned that they would have liked more space, and could have relaxed even more if they weren't infringing on someone else's space. The studio was fairly big, but the arrangement of the mats could have led to restricted personal space. Some participants from one focus group felt it was important to attend classes with people of the same age.		
Balance between having variety and introducing too many new exercises	Participants liked that they covered a variety of different exercises during the taster session, and were not doing the same exercise for extended periods of time, which kept it interesting. There was however mixed views on whether there were too many exercises for an introduction. Introducing a limited number of new postures every week was suggested.		Request for a series of handouts with different postures, or more exercises as participants would eventually tire of these four exercises.
Attire	Some participants regretted not having changed into more comfortable, loose clothing for the session. One said he felt unstable in his socks and should have worn gym shoes or just bare feet. It was felt that it would be good to provide instructions on appropriate clothing and shoes for the session.		A participant did the exercises in normal clothes once, and felt that were too tight. She felt that remembering to wear looser clothes to do the exercises may be tricky.

Instructor	Participants felt that the instructor walked around and was good at adjusting and correcting Found it useful that instructor provided information on which muscles they were working on and other aspects. Found it helpful that instructor demonstrated, and showed the posture to be done immediately and what they were aiming for. One suggestion here is that participants found it easier to follow if the instructor mirrored the class. In the very first session, it was felt that the instructor was working outside his comfort zone, from a piece of paper. The feedback was given to the instructor and the participants in the following sessions did not comment on this.		
Home-based handout had postures already done in the taster with an instructor			Most participants found it helpful that they had done the exercises from the handout previously in the taster session under the supervision of an instructor. They felt the instructor provided a background and more detailed explanations. They were shown what's involved and how to do the exercises correctly.
Clarity		It was felt that the leaflet was clear.	Participants found the handout clear and the instructions easy to follow, with the exception of the warrior pose.

Props		Participants found having a chair in the pictures reassuring.	It was an advantage that no special equipment was required for the exercises, all you needed was a chair which was readily available. Participants found it helpful to use a chair during the sessions.
Home-based handout as acceptable compared to videos			It seemed that some participants preferred handouts while others conveyed an affinity for videos. If time and resources are available, interventions can try to make both alternatives available. However, in case of resource constraints, handouts seemed more widely acceptable and accessible than videos.
Future yoga sessions/continuing yoga	65% of participants agreed or strongly agreed that they would participate in future yoga sessions. They seemed enthusiastic about continuing with yoga, but felt they would struggle to fit it in given other commitments.	Most participants concurred that the leaflet would motivate those who hadn't previously done yoga to give it a try. They felt that it was good starting point to get people curious, and encourage them to participate.	A small number of participants said that if they are given a handout with postures they have done in class, they are likely to practice it at home regularly. One participant said she would do the hamstring stretch on her own.
Yoga promotion strategies			
Lack of information around yoga	Participants felt that the taster session was gave them the opportunity to see what yoga was like without paying a lot of money. The half hour session gave them a good idea of what it entails and they could gauge whether they would like to continue or not. Some participants felt the session had inspired them to explore yoga further, and that they might join a yoga class as they enjoyed it.	From the leaflet they felt they had learnt things about yoga that they weren't aware of, such as its benefits. They also felt that that the leaflet told them what yoga was about.	It was felt that the handouts could capture the interest of those who've never tried yoga, and may encourage them to attend a class. It also gives them an idea of what to expect in a yoga class, and participants felt that they know more about yoga.

Yoga lacks social element		Participants related to the social aspect of exercise, and felt that it was good that meeting people was featured in the leaflet. They also found the mention of tea, coffee and cake appealing.	Class-based preferred due to social interaction
Yoga opportunities	Participants felt they needed to be offered the opportunity to take up yoga. They were interested in a short yoga summer course.	Participants observed that the leaflet did not have any information on where they can do yoga. They felt that it would be useful to have information on the back of the leaflet on places offering yoga, contact details, website, etc. They would find information on the types of yoga that would be suitable for older adults very useful. It is important to add information about the specific programme being promoted, and how it's is geared for an older adult population.	

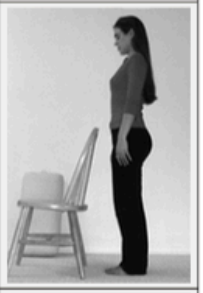
Appendix 38. Example of yoga postures from Tew et al. (2017)



Example of yoga postures from Tew et al. (2017). Reprinted from "Adapted yoga to improve physical function and health-related quality of life in physically-inactive older adults: a randomised controlled pilot trial" by Tew et al., 2017, BMC geriatrics, 17. Copyright, The Authors. Permission not required under Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0/)

Appendix 39. Example of yoga postures from Bonura (2011)

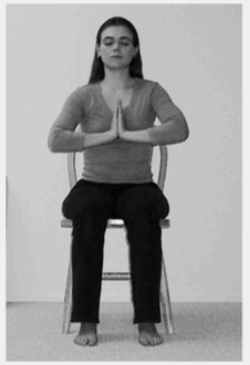
Asana (Yoga Pose)	Purpose	Description	Illustrative Figure
Seated Meditation	Centering and quieting the mind, increasing self-control over thoughts and breathing.	Breathing and meditation. Count the breaths or focus on a chosen mantra while slowing breathing in and out, 2–5 minutes.	
Chest-Opener and Gentle Twist	Opening of the chest and rib cage to improve breathing efficiency. Improved breathing during yoga practice supports better breathing throughout the day, which improves energy levels and alertness.	Seated, place right hand on left knee, and gently twist back to place the left hand behind you on the left thigh, left hip, or back of the chair (as appropriate based on flexibility level). Hold for 5–10 deep breaths. Repeat on the opposite side.	
Side Stretch	Opening of the side body, as well strengthening and stretching of the shoulders and arms. This stretch supports improved ability to maintain self-sufficiency in daily activities such as reaching up to shelves, combing one's own hair, etc., and thus increases self-efficacy.	Looking up toward the hand, lengthening from hip to fingertip, 5–10 deep breaths per side.	

Asana (Yoga Pose)	Purpose	Description	Illustrative Figure
Seated Forward Bend	Forward bends support internal focus and quiet reflection. Forward bends provide calming energy when over-stimulated by external forces.	Spread legs wide, fold gently forward from waist, resting hands on thighs, knees, legs, or ankles, 5–10 deep breathes, quieting of mind takes energy within.	
Mountain Pose	Mountain pose strengthens the legs and torso, increasing physical stability. This physical stability correlates to greater stability of mind and emotions.	Toes turned in slightly, heels slightly apart. Weight centers above arches. Shoulders roll down and back, chest lifts. Eyes close. Work toward stillness of mind and body. Hold for 5–10 breaths up to 10 full minutes.	
Supported Triangle	Triangle pose strengthens the legs and torso while opening the chest, cultivating the complementary forces of strength of purpose and open-mindedness.	Standing beside the chair, feet wide, hand rests on seat of the chair, opposite hand lifts upward; gaze focuses on upper thumb. Hold 5–10 deep breaths. Repeat on the opposite side.	

Asana (Yoga Pose)	Purpose	Description	Illustrative Figure
Supported Chair	Squat improves thigh, buttock, and groin strength, thus promoting greater pelvic floor control. Increased pelvic floor control better supports bladder control and thus can improve self-efficacy for activities of daily living for older adults.	Feet are wider than hip width, knees are bent, tailbone tucked under, abdomen pulled back toward the spine. Gaze and chest lift upward. Hands may hold onto the back of the chair for support; if steady, extend one or both arms up toward the sky. Hold for 5 deep breaths.	
Supported Tree	Balance poses challenge the physical capabilities and increase stability, which can reduce the likelihood of falls and thus further support self-efficacy for activities of daily living. In addition, because of the inherent challenges in balance poses, they teach patience and self-acceptance during the process of attempting any new task.	Stand on left foot. Right foot comes to ankle, calf, or upper thigh with knee turned outward. Hands at the back of the chair for support, or one or both hands may come to center and then extend upward. Hold 5–10 deep breaths, gaze focused at one point. Repeat both sides.	1  2  3 

Asana (Yoga Pose)	Purpose	Description	Illustrative Figure
Standing Cow	Gentle backbend to strengthen the back muscles and open the abdominal muscles, and counteract the normal contraction that occurs due to daily stress and tension. Also important for older women, who may suffer from diminished posture and bone mass to support maintenance of height and strength and thus support self-efficacy for activities of daily living.	Stand beside chair, feet directly above hips, bend at waist and place hands on chair, directly under shoulders. Inhale, lift the chest and chin, lift the tailbone, arch the spine. Breathe gently, 10–15 seconds.	
Leg Lifts	This exercise supports hip/leg flexibility and strength, to improve ability to complete activities of daily living. Hip/leg strength includes balance, ability to independently move to standing from a sitting position, and walk independently. These physical abilities support self-efficacy for activities of daily living.	Lift the right leg forward as high as possible, engaging the thigh muscles; hold for 5–10 deep breaths to cultivate mental and physical endurance. Repeat on the left side. Then, open the right leg out to the right and lift as high as possible, engaging the thigh muscles and hip flexors; hold for 5–10 deep breaths. Repeat on the right side. Repeat both forward and to the side for 2–3 rounds.	
Feet and Hand Stretch	Simple joint mobilization supports improved range of motion and normal functioning for activities of daily living.	Extend arms and legs. Focus on creating space between fingers and toes and extend the joints as far as possible, while inhaling to open up completely. Breathe gently, 10–15 seconds. Exhale, slowly curling in fingers and toes with control and contracting body. Breathe gently, 10–15 seconds. Repeat 2–3 times each side.	

Table 4. *Sample Yoga Sequence for Yoga Class or At-Home Practice*

Asana (Yoga Pose)	Purpose	Description	Illustrative Figure
Seated Meditation, Hands in Namaste	Quiet reflection at the end of yoga practice encourages reflection on how the strength and peace of mind cultivated in yoga can be extended to daily life.	Hands to center for centering awareness, focus on maintaining the sense of calm mind and open body and extending that throughout the rest of the day, 2–5 minutes of diaphragmatic breaths.	

Example of yoga postures from Bonura (2011). Reprinted from "The psychological benefits of yoga practice for older adults: evidence and guidelines" by Bonura (2011), *International Journal of Yoga Therapy*(21), 129-142. Reprinted with permission from International Association of Yoga Therapists and the author.

Appendix 40. Medline search terms for systematic review relating to determinants, correlates, motivators and barriers to physical activity

1. old.mp.
2. “Aged, 80 and over”/or Aged/ or Aging/
3. old*.tw.
4. elder*.tw.
5. physical activity.mp. or Exercise/
6. physical activity.tw.
7. determinants.tw.
8. correlates.tw.
9. motivator*.tw.
10. barrier*.tw.
11. 1 or 2 or 3 or 4
12. physical inactivity .tw.
13. 5 or 6 or 12
14. 11 and 13 and 7
15. Limit 14 to “review articles”
16. 11 and 13 and 8
17. Limit 16 to “review articles”
18. 9 or 10
19 11 and 13 and 18
20 limit 19 to “review articles”